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THE Y-BRIDGE AT ZANESVILLE, O., is being reconstructed as a concrete-steel structure on the Thacher system, and has eight arch spans—three of 88 ft., one of 99 ft., and four of 122 ft. span. The arches are now all completed. The bridge crosses the Muskingum and Licking rivers at their junction, and the old structure (illustrated and described in our issue of Jan. 25, 1900) consisted of Howe truss wooden spans, each span having three trusses and two roadways, which were covered. This original structure was built in 1831. The Osborn Co., of Cleveland, O., are the engineers for the new bridge, the contract for which was let to one of the firms now included in the American Bridge Co., which company sublet the contract to the Bates & Rogers Construction Co. Manhattan Building, Chicago, Ill., by which firm the work is now being executed.

IN THE LOOP TUNNEL on the Canadian Pacific Ry., near Crow's Nest Pass, B. C., the headings were lately joined. This 900-ft. tunnel is driven through a very loose gravel hill, and on a 10° curve compounding about the center with an 11° curve. The levels and alinement were found to meet perfectly, and the completion of this tunnel will much improve this section of the road. We are indebted for this item to Mr. C. R. Coutlee, Engineer in Charge.

THE UGANDA RY., in East Africa, is reported as nearly completed to Lake Victoria Nyanza. To this point the road is already ballasted, and for this line the American Bridge Co. has just secured the contract for 20 steel bridges. This work was authorized by the English Parliament in 1896, the line to be built at the cost of the nation for an estimated total of about $12,000,000. On March 1, 1900, 360 miles of track had been laid from Mombasa, on the Indian Ocean; out of the 581 miles to Port Florence, the terminus at the Lake, only 64 remained to be built on Aug. 5, 1901. But the total cost of the railway and its equipment will be about $24,750,000, or more than twice the estimate. Transportation upon and across Lake Nyanza will be by steamboat, and one boat has already been transported there in sections at an enormous cost, and two more will be carried by rail. The purpose of this road is to cheapen transport to the interior by native carriers, which is now so costly that one ton of cotton cloth worth $570 on the cost is worth $3,420 in Uganda. The road has been built entirely by labor brought from India, and its opening is expected to enormously develop trade.

HARDWOOD SPIKES or spike plugs are being tried on several railways in France, to increase the holding power of ordinary and screw spikes when driven in ties of Baltic pine, and other soft woods. Holes about 1.37 ins. diameter are bored in the tie, and tapped to receive screws of hardwood 1.37 ins. diameter at the bottom and 2 ins. at the top, each with an iron band to prevent splitting. The wooden screws are hollow and the iron spikes or screw spikes are driven into them. The increase in holding power is said to be from 30 to 40% for new pine ties, while in old ties it is from 33% for beech, to 62% for oak and 80% for pine. The hardwood plugs also prevent the tie-plates from cutting into the softer ties. This method is the invention of Mr. Albert Collet, who has devised special machinery for making the screw plugs at very low cost.

THE PAN-AMERICAN RY. CO., says U. S. Consul Canada, of Vera Cruz, has received a concession from the Mexican government for building a railway from San Geronimo, a station near Tehuantepec on the railway of that name, to the border of Guatamala, with a branch road from the port of Tonala to Chiapa de Corso, the capital of the State of Chiapas. The concession is for 99 years, and the government pledges itself to pay $12,000 for each kilometer built and approved by the Department of Public Works. The company must build at least 50 kilometers, or 31 miles, in the first year, and 50 miles in each succeeding year, completing the main line in six years.

THE NEW ECUADOR RAILWAY was opened on Nov. 17 from Bussay to Quibi, a distance of 22 miles, over the most difficult part of the line to Quito, from an engineering point of view.

PRESSED AND DRIED PEAT FOR LOCOMOTIVE fuel is being experimented with on the Vislanda-Bolmen Ry., of Sweden. In a late test, though the engine was built for using coal only, an experimental train of 15 freight and one passenger car made the 22-mile trip ahead of the regular time schedule, arriving at the terminal station 15 minutes in advance of the schedule. A time-table for lower speed than the regular train had been arranged.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision on the Atchison, Topeka & Santa Fe Ry. at Franconia, Ariz., on Nov. 20, between an east bound and a west bound limited passenger train. Both trains, one a double-header, were running at a high rate of speed, and the collision wrecked both trains completely, the forward sections being almost totally destroyed. Seven persons, all belonging to the crews of the two trains, were killed outright, and over a dozen injured. The west bound train was two hours' late and arrangements had been made for the two trains to pass at a siding; but the orders were disobeyed by one of the trains, resulting in the collision.

A GROUNDING DEVICE FOR TROLLEY WIRES for use at fires will be put into use in San Francisco, Cal., shortly. It consists of a long pole, carrying within it a conducting wire provided with a switch, the pole having its end formed into contact pieces. When it is to be used the pole is placed so as to connect the trolley wire with the track and the switch then thrown; this short circuits the line-current and throws the automatic circuit-breaker in the station, entirely cutting out the corresponding section of line. The device is intended to prevent shocks to firemen resulting from the stream of water coming in contact with a live trolley wire. It was designed by Mr. W. R. Hewitt, of the department of electricity of San Francisco.

MARCONI WIRELESS TELEGRAPHY is to be experimented with on the Newfoundland coast, and Mr. William Marconi is now in St. Johns for this purpose. The problem is a difficult one, as weather conditions are notoriously bad in that region and electrical disturbances are frequent. To avoid the expense of erecting tall masts, he will carry on his experiments by means of two anchored balloons of 20,000 cu. ft. capacity each. The sea-station will be on a steamer equipped with a 120-ft. pole. Among the things to be studied are the effect of rocky shores, enclosed bays and fog, and also the remedy for electrical disturbances, at present the most aggravating obstacle in the way of aerial communication.

THE COMMERCIAL CABLE CO., organized to lay a Pacific cable, is pushing its enterprise. As already noted, it has contracted with an English company for making and laying the San Francisco-Honolulu section for $3,000,000. This section is to be in operation in about 10 months. The U. S. Attorney-General is said to have given an opinion that so far as the government is concerned no obstacle will be put in the way of laying a cable between points on United States territory. The total length of the cable will be 7,000 to 8,000 miles to Manila; and the cable should be in working order to the Philippines within two years. Mr. Mackay, the head of this American cable company, says that while this cable will be built by private enterprise, in time of war it could be under government control, and he thinks that both the government and the public would have better service at reasonable rates than if it were under permanent government control, as better working arrangements could be made with other lines.

A LONDON-AMERICAN SEVEN-STORY OFFICE PROject is under consideration by the London County Council on the application for a lease of a site on the Strand for 999 years. So far, the permit is refused, for reasons not plain to American readers. The Anglo-American syndicate proposing to erect this building includes Sir Charles Rivers Wilson, the Earl of Kintore, Earl Grey, George Cornwallis West, of London, and F. H. Esler, of New York. The land asked for has a frontage of 750 ft. on the Strand, and it is proposed to erect thereon a lofty office building thoroughly equipped on the latest American lines. The estimated cost is $10,000,000. Mr. Esler says that at present British public opinion condemns "skyscrapers," but the plans will be so made that other stories can be added to this first building as soon as the public is educated up to that point.

THE ENGLISH WORKS of the Westinghouse Electric Co., at Trafford Park, near Manchester, are nearing completion, and are expected to be in operation early next year. The corporation building them is known as the British Westinghouse Electric & Mfg. Co. The works are being equipped with American machinery and American appliances for heating, ventilation, etc. The works will comprise six main buildings, of which the largest is a machine shop, 430 × 900 ft., said to be the largest in Great Britain.

FIFTEEN HOURS UNDER WATER IN THE SUBmarine boat "Fulton" were comfortably spent by seven men in an official test of the boat on Saturday night last. The trial was made in the dock at Greenport, L. I., to test the value of the air supplying device and the length of time the boat could continuously remain under water. Among the men who made the test were Rear-Admiral John Lowe and Lieutenant Arthur MacArthur, U. S. N., and Mr. F. T. Cable, of the Holland Co. On coming to the surface again they reported the air as good as when they went aboard and little of the stored air used. They could have remained much longer in the submerged boat without discomfort.

RIVET-TESTING BY FILLING SHIPS WITH WATER is the plan followed by the Morse Iron Works & Dry-Dock Co., of South Brooklyn. A triple-cylinder pressure pump, operated by electricity, is equipped with a 10-in. suction and 7-in. discharge pipe. With a ship hauled up on the dry-dock and repaired by replacing—perhaps, several thousands rivets—the tightness of these new rivets is tested by flooding the hull with water, up to the tanks, by the aid of the pump described. It is stated to be a great labor-saving device, as under old methods the integrity of the riveting was only known when the ship was launched again. The same pump is fitted with a fresh water pipe system to fill boilers and ship tanks.

DRY-DOCK NO. 2 AT THE NEW YORK NAVY YARD, recently rebuilt in cement, is said to be practically beyond repair. The water enters the dock between the cement work and the sheet piling; and some of the piling has decayed so as to create large crevices. This was originally a timber structure—and has cost the government a large sum in construction and various repairs.

THE WILLIAM SKINNER SHIP-BUILDING & DRY-Dock Co., of Baltimore,, Md., formally opened the second largest dry-dock in this country on Nov. 25. The dock is built of timber, carried on pile work, and the entrance is granite masonry backed by concrete. The steel caisson-gate gives an opening 80 ft. wide at the top, with 22½ ft. of water over the sill. The general dimensions of the dock are as follows: Length over all, 628 ft.; length on keel blocks, 600 ft.; width of entrance at bottom, 60 ft.; at top, 80 ft.; width of dock on floor, 62 ft.; width at coping, 125 ft.; depth of water over sill, at low water, 22½ ft.

THE TRANS-CAUCASIAN PETROLEUM TRANSPORT is thus noted in the "Frankfurter Zeitung" of Oct. 24: The chief railway system for this purpose is the Baku-Batum line of 558 miles, with double-track for two stretches of 100 and 62.3 miles. This railway owns 1,000 tank cars of 3,750 gallons capacity each and about 3,400 cars of 3,050 gallons each. Allowing 13 days for the round trip, this road could transport annually to Batum 400,000,000 gallons, though owing to the frequency of train accidents 300,000,000 gallons is the maximum handled per year. Since October, 1900, a pipe line 142½ miles long has been in operation between Michallova and Batum, but it is carelessly managed, and only handles 19,000,000 gallons per month. By the end of 1902 another 80 miles of pipe line will be added to this, and an Imperial order was issued in July, 1901, to complete the remainder of the pipe line, or 311 miles. The completed system would have a capacity of 625,000,000 gallons per year, and the estimated cost per pipe line in 0.6 cts. for a "pood" of 5 gallons, as compared with 2 cts. per pood by railway. With this pipe line completed, the Russians hope to successfully compete with the American petroleum industry in the markets of the world. Russia supplied 35% of all the petroleum used in 1900, or 365,000,000 gallons.

A REFLECTING HAND-LEVEL, adapted for mounting on a Jacob's Staff, is made by F. Weber & Co., 1125 Chestnut St., Philadelphia, Pa. It is essentially the Locke hand-level, fitted with a simple appliance for mounting on the staff and an equally simple single-screw leveling device. Another form has a graduated circle and vernier for reading circular angles.

THE DEVELOPMENT OF SHIPYARD CRANE SERVICE.

By Henry P. Jones.*

In approaching the subject of shipyard development from any one of the many points of view it is difficult to eliminate the mass of interesting data which careful study on the part of various authors has placed at hand and which, though not directly relevant, yet so clearly traces the lines of cause and effect. The factors which now make it possible to transport a ton of cargo 100 miles with a consumption of but 4 lbs. of fuel where 10 lbs. were required a decade ago, are responsible for the improvements now demanded in handling the material which goes to make up the completed steamship. Higher steam pressures and more economical engines have cut down the fuel consumption, which in itself does not increase in direct proportion to increased cargo capacity, thus economy in operating has been sought in steamers of greater size, the development progressing even more rapidly than the shipbuilders' methods of handling the materials of construction.

The greater heights to which material must be lifted, together with the demand for greater span or overhang, due to increased beam, are important factors in the work of ship construction, which may be divided into two general classes, namely, that done while the ship is on the ways at the building berth, and that done after launching and while the ship is laying at the fitting-out wharf. The crane equipment for these two classes of service differs widely both as regards arrangement and capacity, and though the building-berth service may be considered more important as regards the percentage of total work done, yet the capacity required at the fitting-out wharf greatly exceeds that demanded by the building-berth cranes.

It is the writer's purpose to discuss, at this time, only those cranes used in carrying on the work at the fitting-out wharf, leaving for future consideration the various designs of equipment for building-berth service. A brief reference to conditions which influence the proportion of work done before and after launching is, however, of interest.

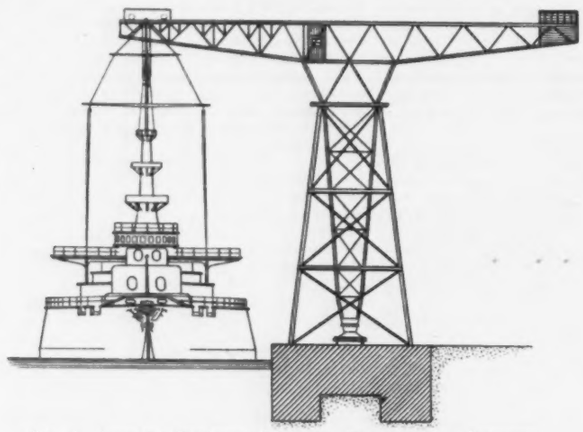

Fig. 1. Imperial Dockyard Crane at Bremerhaven, Germany.

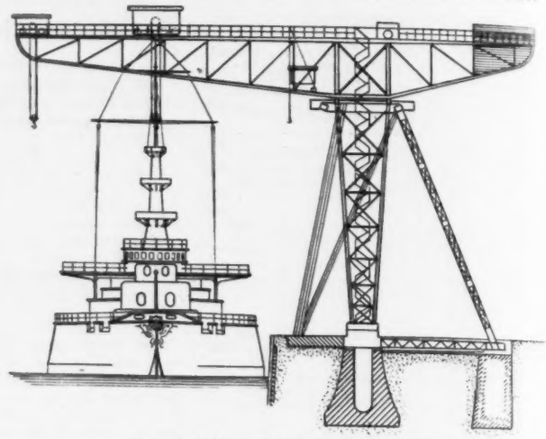

Fig. 2. Krupp Crane at Kiel, Germany.

TYPES OF REVOLVING CRANES FOR SHIPYARD SERVICE.

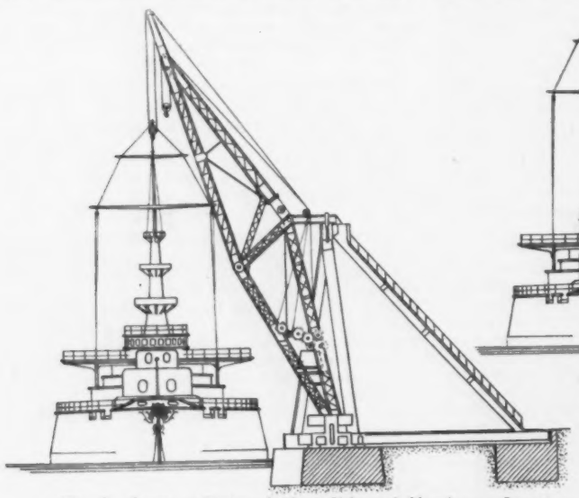

Fig. 3. Crane at Blohm & Voss Shipyard, Hamburg, Germany.

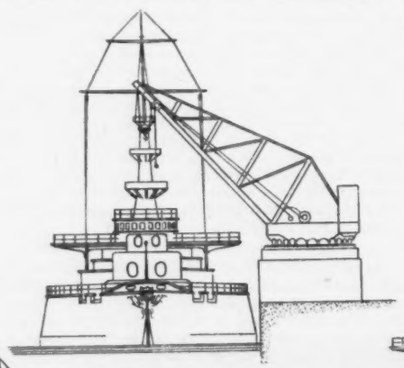

Fig. 4. Revolving Jib Crane at Naval Construction Works, Devonshire Dock, Barrow, England.

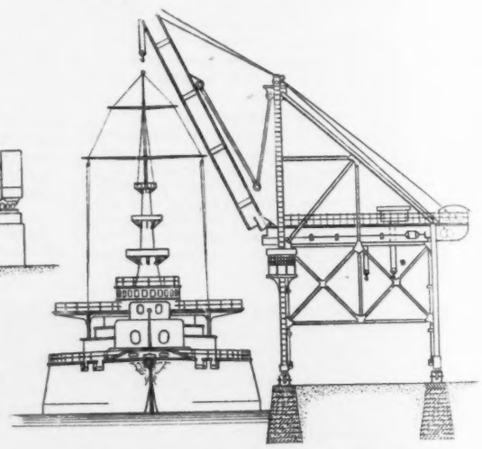

Fig. 5. Gantry Crane for Fore River Yards.

TYPES OF JIB CRANES FOR SHIPYARD SERVICE.

*Quincy, Mass.

TABLE I.—Launching Data.

	Ship.	Launching weight, tons.	Normal or light displacement, tons.	Normal displacement, less normal coal supply, tons.	Builders finished weight, tons.	Per cent. of completion at launching.	Pressure on ways per sq. ft., tons.
Group 1	U.S.S. "Kearsarge"	4,450	11,540	11,130	.....	39.98	2.25
	" "Kentucky"	4,450	11,540	11,130	.....	39.98	2.25
	" "Illinois"	4,350	11,565	10,765	.....	40.41	1.94
	" "Iowa"	4,498	11,340	10,715	.....	41.98	1.83
	" "Oregon"	4,100	10,288	9,888	.....	41.46	2.57
	" "Massachusetts"	3,712	10,288	9,888	.....	37.54	2.85
	" "Texas"	2,449	6,315	5,815	.....	42.12	2.62
	" "Olympia"	2,400	5,870	5,470	.....	43.88	3.064
	" "Raleigh"	1,360	3,213	2,863	.....	47.50	2.97
	" "Helena"	715	1,397	1,297	.....	55.13	1,198
Group 2	H. M. S. "Ocean."	7,110	12,350	.....	.....	54.90	2.5
	H. M. S. "Niobe"	6,300	11,070	.....	.....	56.91	1.84
	I. J. M. S. "Fuji"	7,500	12,450	.....	.....	60.24	2.50
	Warship No. 1.	6,370	.....	.....	8,350	76.29	....
	" " 2.	6,520	.....	.....	8,560	76.17	....
	" " 3.	7,460	.....	.....	10,140	73.57	....
Group 3	"Oceanic"	11,000	28,500	.....	.....	38.60	2.35
	"Deutschland"	9,200	23,000	.....	.....	40.00	....
	Merchant ship No. 1.	3,750	.....	.....	4,740	79.11	....
	" " " 2.	2,120	.....	.....	2,566	82.62	....
	" " " 3.	5,440	.....	.....	8,250	65.94	....

While the intensity of the load upon the launching ways is an important factor, yet it is within control of the shipwright; and local conditions at the shipyard, as represented by building-berth crane equipment and demand for building-berth space, or for wharfage at the fitting-out slip, will largely govern the percentage of completion at the time of launching.

The accompanying Table I. has been compiled from published records of launchings, and though it is to be regretted that accurate data concerning builders' finished weight is unavailable in a majority of the instances cited, yet the use either of the light displacement, or of the normal displacement less the normal coal supply, will serve for purposes of comparison.

Group 1 comprises ten vessels of the U. S. Navy

TABLE II.—Subdivision of Launching Weight.

	Ship.	Weight at launch. Hull, tons.	Weight at launch. Mach'y, tons.	Per cent. of launch'g w't. Hull.	Per cent. of launch'g w't. Machinery.
U.S.S.	"Illinois"	3,908	141	89.84	3.24
"	"Iowa"	4,038	283	89.77	6.29
"	"Texas"	2,199	70	89.79	2.86
"	"Raleigh"	1,157	46	85.07	3.38
"	"Helena"	562	108	83.36	15.10

and gives the percentage of completion at time of launching, based upon launching weight and normal displacement less normal coal supply.

Group 2 gives the percentage in connection with certain warships built abroad, and although the use of builder's finished weight or of normal displacement, without deduction for coal supply would naturally give a percentage of completion lower than the actual, yet the results are considerably higher than in Group 1.

for the water-tube boilers for the above ships will each weigh about 20 tons.

In building merchant steamers the conditions are somewhat different, the adoption of water-tube boilers not having become general, as in the case of warships, and therefore heavy loads are encountered in placing large cylindrical boilers on board; also the general design of the engines for merchant ships tends toward greater height and less floor space—the use of tandem cylinders

for lifting heavy loads, and even at the present time the number of sheers in active operation probably exceeds that of all other types of cranes; but with the demand for greater speed of operation and for increased field, many powerful cranes, mainly of the revolving type, have been designed, all meeting more or less fully the requirements of capacity, field of operation, speed, precision and economy.

Probably the simplest form of revolving crane

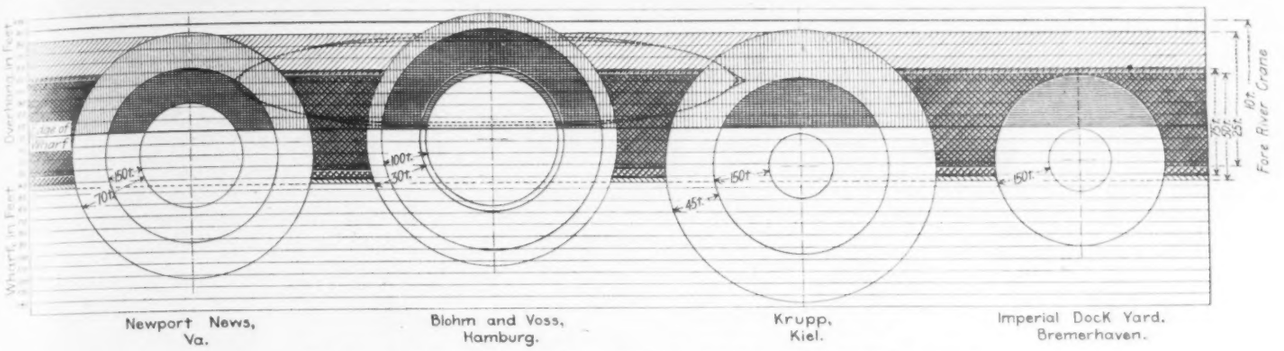

FIG. 6. PLAN SHOWING AREA COVERED BY THE CRANES IN FIGS. 1 TO 5.

Group 3 gives the percentage for certain merchant ships, and is notable principally for the wide variation, which is characteristic of vessels designed for different kinds of merchant service.

It is probable that Group 1 fairly represents the average conditions in warship construction, the weight of the launching cradle, etc., included in launching weight, serving as an offset to certain weights included in normal displacement and not chargeable to the finished weight of the ship, considered as an engineering structure. It is evident that the amount of work to be done after launching, and while the ship is at the fitting-out wharf, represents a considerable proportion of the total, though varying according to the class of ship and also according to local conditions.

As regards the distribution of work between the hull and engineering divisions of a shipyard, the proportion of the latter has been estimated as varying from 24 to 30% of the total, while in connection with the relative proportion of weight coming under the direction of the engineering division, it may be stated, that in the case of the 15,000-ton battleships "Rhode Island" and "New Jersey," now building at Fore River, the proportion amounts to a little less than 11% of the total.

Table II. shows four instances of the relative proportion of hull and machinery weights at the time of launching, and it will be seen that the latter are comparatively small, subject, however, to increase as the size of the ship decreases. In case of warships, it has been estimated that an average of not more that 3% of the total engineering work is on board at the time of launching, and this percentage is very little greater in merchant ships. It seems reasonable to believe that this percentage will increase with the development of the building-berth equipment.

In battleship construction, the heaviest weights are those of the armament and armor, and engines, if the latter are assembled within the shop and transferred to the ship in that condition. In case of the "Rhode Island" and "New Jersey," each of the 10-in. barbette armor plates will weigh about 25 tons, and the 12-in. guns 74 tons each, with sleeve, or 67 tons without sleeve. One of the engines will weigh, assembled, somewhat more than 100 tons, and as to the economy of handling it in that condition, certain constructive features pertaining to the ship itself must be considered. The lateral distribution of the engine bulk, together with comparatively small hatchways, necessitates the removal of the decks, which must be at least bolted in place at the time of launching, therefore, reassembling of the engine may be avoided at the expense of additional hull work. If the engines are placed on board in partially assembled sections, the heaviest will be that of the intermediate and low-pressure cylinders, weighing about 28 tons. The sections

being permitted by the elimination of protective requirements and deck space being economized, particularly in steamers carrying passengers, and this vertical distribution of engine bulk, together with increased size of hatchways, facilitates the placing of the engines aboard completely assembled.

The engine and boiler equipment of the modern battleship has so well emphasized the marked progress which has been made in the direction of securing greater power from a given weight, that it seems reasonable to believe that designs which

is that of the derrick type, having a jib with fixed radius, and the 130-ton crane erected at Finnieston Quay, Glasgow, in 1893, is stated to have represented the best English practice at that time. As the field of operation of such a crane is restricted to a circular path at the fixed radius, designers naturally turned their attention to some means of varying the radius and thus increasing the field. Two methods of effecting this result have been adopted—that of raising and lowering the jib, and that of moving the hoisting tackle to and from the center along a horizontal jib.

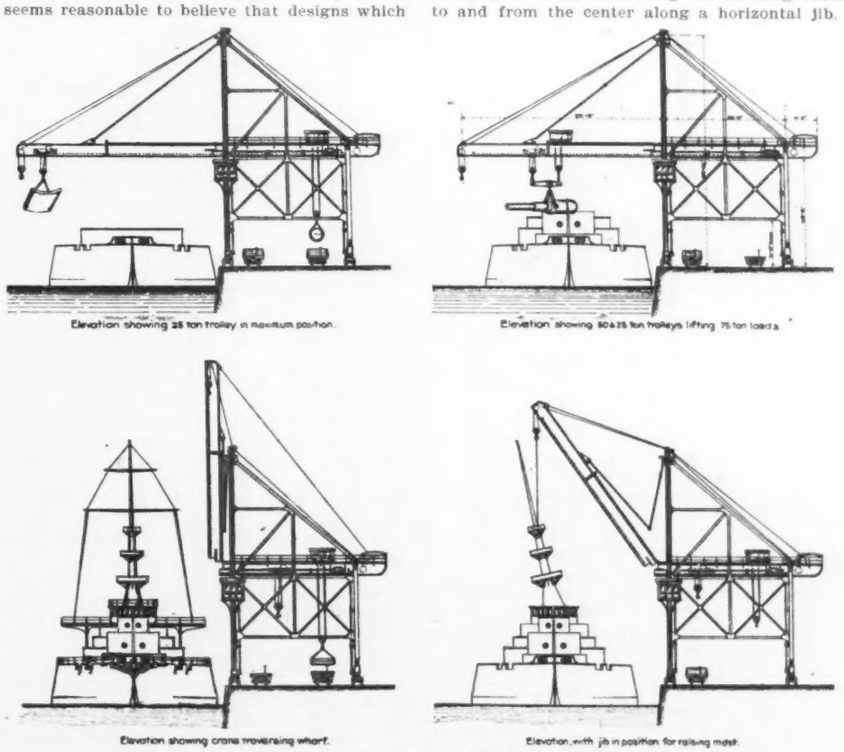
Elevation showing 25 ton trolley in maximum position.
Elevation showing 50 & 25 ton trolleys lifting 75 ton load.
Elevation showing crane traversing wharf.
Elevation, with jib in position for raising mast.

FIG. 7. ELEVATIONS OF FORE RIVER CRANE IN VARIOUS POSITIONS.

lead to important reductions in weights will in the near future be very generally adopted for many classes of merchant ships.

Having considered the amount and character of the service to which the fitting-out crane must be adapted, it is interesting to review, briefly, certain types which have been designed and constructed.

Until a comparatively recent date some form of sheer legs was practically the only device used

The Newport News crane (illustrated in Engineering News of Feb. 23, 1899), and similar in general appearance to the design shown in Fig. 4, is an excellent example of the first class. The Blohm & Voss crane, shown in Fig. 3, also belongs to this class, though the raising and lowering of the jib is effected by a somewhat peculiar design, and the crane is apparently not capable of a complete revolution.

Of the second class there are several notable

examples, among them the Krupp crane, shown in Fig. 2, and the Imperial Dockyard crane, shown in Fig. 1.

The plan or diagram, Fig. 6, is intended to show the field of operation of each of these four cranes, and it is at once evident that the horizontal jib with moving hoisting gear covers the entire area included within the maximum radius, while in cranes that vary the radius by the raising or lowering of the jib, the space included within the minimum radius is not in the field of operation.

There is shown in Fig. 6, under the Blohm & Voss crane, the outline of a 15,000-ton battleship of the "Rhode Island" and "New Jersey" class, and it will be seen that a large proportion of a ship is beyond the field of a revolving crane, and therefore can be reached only by warping the vessel along the fitting-out wharf.

In shipyard work, where the rapid and economical handling of material so vitally affects the profits, the necessity of thus bringing the ship to the material instead of the material to the ship, is manifestly a condition to be avoided, particularly in case of ships of great length, or where it is desirable that work should be in progress upon two or more vessels at the same time, with the crane service available to each.

In this connection we may direct our attention to the value of efficient means of delivering materials to the crane. In establishing an intimate relation between the transportation system of the shipyard and the fitting-out crane, the disposition of that portion of the field of operation which falls over the wharf itself, becomes of importance, for not only must incoming and outgoing cars be provided for, but also space for more or less rough assembling of heavy parts, which it is frequently desirable to carry on within the wharf area covered by the crane. An inherent disadvantage of the revolving crane is the limited frontage afforded by its circular field, for such purposes.

From the above review of general conditions, it will be seen that increase in field, together with an improvement in the disposition of same, required a radical departure from the revolving type of crane, and, as an example of one of the latest and most interesting designs, in fact, so far as we are aware, the only design effecting the desired results, we reproduce in connection with this article, certain drawings of the folding jib gantry crane designed and built by the Wellman-Seaver Engineering Company, of Cleveland, O., to meet the conditions laid down by the Fore River Ship & Engine Company, of Quincy, Mass.

This crane, while having a nominal capacity of 75 tons, has an actual capacity considerably in excess of that figure, ample provision having been made for all strains due to weight of framework, counterweights and live loads. The drawings show very clearly the scope of the general design, in which has been ingeniously combined the advantages of the gantry, the cantilever and the derrick types.

A reference to Fig. 5, drawn to the same scale as Figs. 1, 2, 3 and 4, will convey an idea of the comparative size of the Fore River crane, though it should be added that the mean low water line is below that shown, giving 66 ft. in the clear when boom is horizontal, and about 140 ft. to hook of masting tackle as suspended over the center of the largest battleship.

It is evident that the field of operation of such a crane can be extended along the wharf indefinitely, and the lateral limits are shown in Fig. 6, which, however, does not show the entire wharf length along which the crane will operate.

The lateral traverse for the heavier loads is about equally divided between ship and wharf, and material can be unloaded from cars on either of the two railway tracks shown, and swung between the legs of the "A" frames directly aboard the ship. Ample space remains between the legs for assembling and storage, and the lower strut of the bracing between "A" frames is removable, if clearance greater than 21 ft. above top of rail is desired; thus, by raising the boom to a vertical position the crane can be traversed along the wharf without interfering with the ships or the wharf or with cars or material on shore.

One feature of the transportation system, not shown by the drawings, but closely related to this fitting-out service, is a runway built below grade by means of which an assembled engine may be delivered from the adjacent machine shop directly to the gantry crane and thence to the ship.

Of equal importance with the general adaptability of the design, is the question of speed and economy in operating, and, for the purpose of aiding the description, Table III. has been prepared from data concerning this and other cranes, and it will be observed that the speeds of the former are fully in keeping with the increasing demand for rapid work. The last column accurately represents the work done on the load, and the motor power available for the different loads gives, in addition to

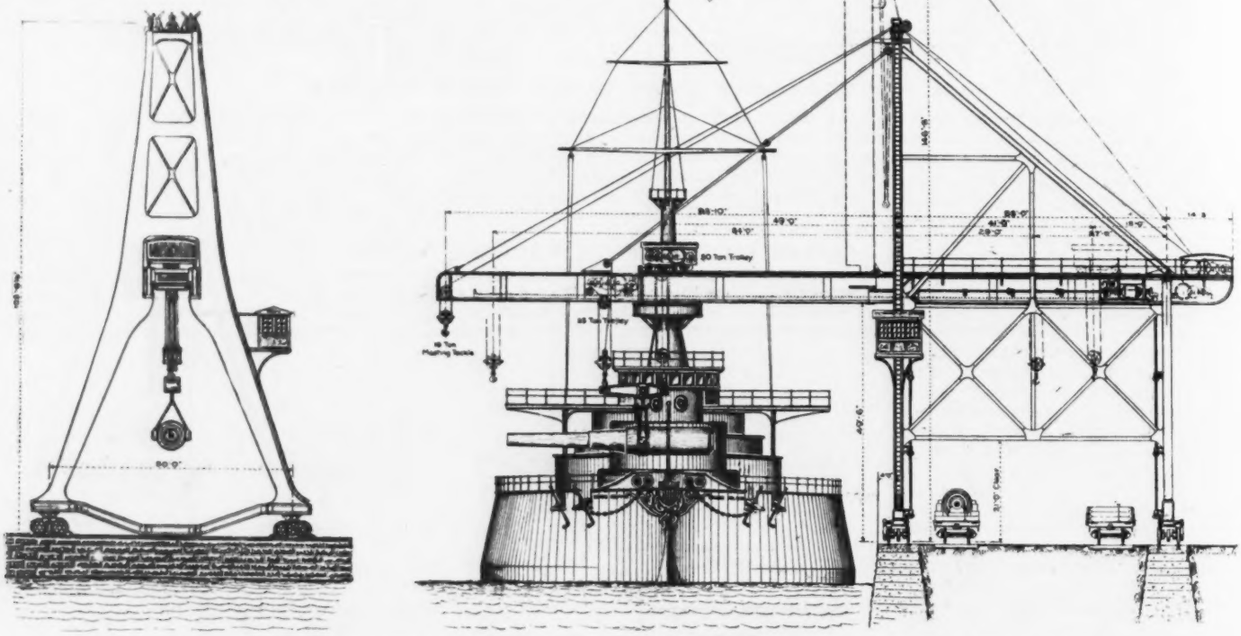

FIG. 8. FORE RIVER CRANE IN POSITION FOR FITTING OUT BATTLE-SHIP OF "NEW JERSEY" CLASS.

TABLE III.—Power Equipment, Speeds, and Work Done by Various Cranes.

	Operation.	Load.	Speed.	Power of motor.	HP. absorbed by load.
Fore River (electric).	Traverse of crane on track	None.	165 ft. per min.	100 HP.	.....
	Traverse of crane on track	Full.	57½ " "		
	50-ton trolley, hoisting	"	11 " "	50 "	37.33 HP.
	50-ton " traversing	"	75 " "	25 "	.....
	25-ton " hoisting	"	22 " "	50 "	37.33 HP.
	25-ton " traversing	"	150 " "	25 "	.....
	Fall tackle, hoisting	"	25 " "	25 "	16.97 HP.
	Raising boom	.....	21 " "	50 "	.....
Blohm & Voss (steam).	Large hoisting gear	50	8¼ " "	90 HP.*	28.85 HP.
	Large " "	100	4¼ " "		28.85 "
	Small " "	10	39 " "		26.47 "
	Small " "	30	13 " "		26.47 "
	Revolving power	.....	...	46 HP.*	.....
Newport News (electric).	Jib controlled by two 100 HP.	.....	...	200 "	.....
	Two main 75-ton hoists, by (2) 100 HP.	.....	...	200 "	.....
	One 20-ton hoist	.....	...	100 "	.....
	Revolving power, two 20 HP.	.....	...	40 "	.....
	Jib, lowest to highest position	None.	6.9 minutes.	.....	.....
	Right hand hoist	68	6.07 ft., min.	100 HP.	28.00 HP.
	Left hand hoist	66	7.01 "	100 "	31.40 "
	Whip hoist	19.2	52.41 "	100 "	68.30 "
	Revolution	134	3.38 minutes.	40 "	.....
	"	68	3.36 "	.....	.....
	"	None.	3.04 "	.....	.....
Imperial dockyard Bremerhaven (electric).	Traverse of 150-ton trolley	.....	...	26 HP.	.....
	Two hoists, two 40 HP.	.....	...	80 "	.....
	Revolving power	.....	...	26 "	.....

*Assuming 40 lbs. M. E. P. and 180 revs. per minute.

the power absorbed by the crane itself, an ample margin for contingencies.

Credit is due to the designers for the careful attention to detail, which is characteristic of the entire structure. Particular attention has been given to the hinged joint connecting the boom to the main girder, it being so arranged that with the boom in a horizontal position, no strains from the weight of the boom or live load can come upon the pins, the strains being taken up by offset joints in the webs.

The trucks upon which the crane travels are so arranged that an equal distribution of weight is obtained, and a brake and a locking device are provided to arrest the travel and secure the crane at any desired point. The operator's cage commands a clear view of the situation and the means of electrical and mechanical control have been designed with special reference to severe and continuous service and perfect control of all movements. The main hoist is provided with electrical and mechanical brakes, thus efficiently guarding against all possibility of running down of the load due to loss of current or other causes.

As before stated, the crane represents a marked advance in shipyard methods, and, unless we include the small gantry of 40 tons capacity at the Brooklyn Navy Yard, and certain floating cranes, it is the only service permitting the traversing of heavy loads along the wharf front to any desired point with speed and economy.

The structure is an excellent example of the established policy of the company for which it has been built, namely, to adopt labor-saving methods of carrying on ship-building work, which shall represent the best modern practice and thus to keep pace with marine progress which, during the past ten years, has effected an increase of 10⅔% in I. HP. per ton of machinery, and of 13% in highest sustained ocean speed, accompanied by a decrease of 14⅓% in coal consumption.

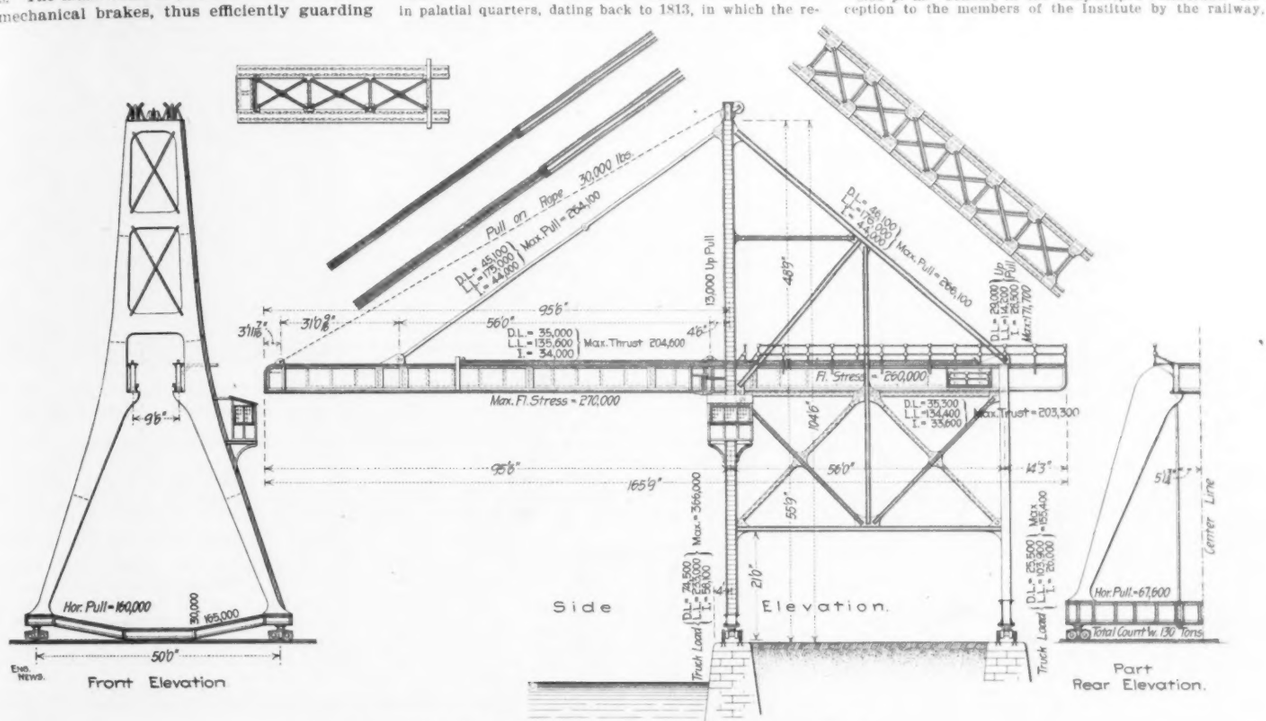

FIG. 9. DETAILS OF FORE RIVER CRANE SHOWING STRESSES.

THE AMERICAN INSTITUTE OF MINING ENGINEERS IN MEXICO.

(Continued from p. 396.)

Mexico City, Nov. 16, 1901.

An hour or two before reaching Mexico City we were told that we must be in our dress suits by 6 p. m. to take carriages from the railway station to the School of Engineers, where the first formal session of the Institute would be held, and that it was very important that everyone of the party should be present on time, 6.30, out of courtesy to our distinguished hosts, who are extremely punctilious about matters of etiquette. As we arrived at the station at 4 p. m., there was an hour or so at our disposal before we had to begin dressing, and we availed ourselves of it by taking cabs to visit the business section of the city and call for our letters at the ticket office of the railway company. By 7 o'clock we were all in our seats in the splendidly carpeted audience hall of the School of Engineers and for nearly two hours listened to speeches of welcome and a response by President Olcott, all delivered in Spanish, which not one in forty of us understood. Thus we performed the obligation which courtesy imposed upon us.

We were amazed at the magnificence of the building occupied by the School of Engineers. It is more like a palace than a school. It was originally intended for a school of mines, and was completed as long ago as 1813. It now has 180 students of civil, mining and mechanical engineering who occupy only part of the building, the remainder being devoted to a national school for boys, to the office of the Minister of Fomento, and to other purposes. If any of our party previously had an idea that Mexico was behind the United States in educational matters he has been converted to the contrary opinion by what we have seen. Here is an engineer's school housed in palatial quarters, dating back to 1813, in which the requirement for admission is a bachelor's degree in an academic college, a higher requirement than that of any engineering school in our country.

Mexico is also ahead of us in one branch of governmental administration. It has a Minister of Fomento, the Spanish word having the same root as our rarely used word foment. It means something like our word encouragement, and the work of the department of this minister has the same relation to all the industries of Mexico that our Department of Agriculture has to one single industry. Why has not the United States a department of industry, including agriculture, mines, manufactures and commerce?

Our welcome in Mexico City has surpassed our highest expectations. It has been one grand round of visits of inspection, entertainment and festivity. For a description of the city, one of the finest in the world, I must refer to the excellent pamphlet guide compiled by Robert S. Barrett, and published by the Modern Mexico Publishing Co., price 50 cts. U. S. currency, copies of which were presented to each of us by the local committee. For the program of our visit, which we have endeavored to carry out as far as our endurance would permit, I can only give the program itself, which is as follows:

PROGRAM.

First Day.—Saturday, Nov. 9, 6.30 p. m. Examination Hall of the School of Engineers, San Andres St.—Formal inaugural session of the meetings and reception of the members of the American Institute of Mining Engineers by the Minister of Fomento, Engineer Leandro Fernández and by the Academy of Sciences, the Association of Engineers and Architects of Mexico and by the School of Engineers. Official speech of welcome delivered in the name of these technical societies by their delegate, Engineer Agustín Aragón. Orchestra of the National Conservatory of Music of Mexico.

Second Day.—Sunday, Nov. 10.—No program.

Third Day.—Monday, Nov. 11, 9 a. m.—Technical session in the Salon de Actos of the School of Engineers. In the first place, reading of the articles that the Ministerio de Fomento offers to the Transactions of the Institute.

11 a. m.—Visit to the School of Engineers, including the library in the old chapel, Hall of Models, Meteorological Observatory and to the mineralogical and geological cabinets. Panoramic view of the city.

12 a. m.—Visit to the National Library, Cathedral, etc.

3 p. m.—Pleasure trip in special electric cars to Tlalpam, Coyoacán, San Angel, Mixcoac and Tacubaya.

9 p. m.—Reception given by the Ayuntamiento of the City of Mexico to the members of the institute and their families in the Municipal Palace, presided by the Hon. Guillermo de Landa y Escandon, President of the Ayuntamiento and Honorary President of the Local Committee.

Fourth day.—Tuesday, Nov. 12, 9 a. m.—Technical session in the Salon de Actos of the School of Engineers.

11 a. m.—Visit to the National Museum.

2.30 p. m.—Visit to Chapultepec in special electric cars and by carriages to the castle. Reception by President Diaz, followed by visit to the Cathedral of Guadalupe in special electric cars.

9 p. m.—Reception given by the American colony to the members of the Institute and their families at the American Club.

Fifth Day.—Wednesday, Nov. 13, 8 a. m.—Visit in special train over the Hidalgo & Desaglie Railways, to the drainage works of the Valley of Mexico. Mexican breakfast at Zumpango.

8.30 p. m.—Concert in the Chapultepec restaurant. Reception to the members of the Institute by the railway, banking and mercantile circles of the city, as well as by the engineers of the city.

Sixth Day.—Thursday, Nov. 14.—All-day trip by special train on the Mexico, Cuernavaca & Pacific Ry. to Cuernavaca, 74 miles, and return.

Midnight.—Leave Mexico City for Pachuca, due to arrive there 7 a. m. Friday.

At the session for the reading and discussion of technical papers, held in the auditorium of the School of Mines on Nov. 12, the following papers were read by title: "Notes on the Mines and Minerals of Guanajuato," by Wm. P. Blake, of Tucson, Arizona; "The Value of Ores in Mexico," by N. H. Emmons, and "The Coal Fields of Los Esperanzas, Coahuila," by Edwin Ludlow, of Coahuila. The mines described in the last-named paper have now attained an output of about 1,200 tons per day, and supply the demand for coal for railway use and steam-making purposes throughout northern Mexico. In southern Mexico this coal meets competition from West Virginia coal, sent by water to Tampico and Vera Cruz.

"Mexican Railroads and the Mining Industry" was the title of a paper read by Mr. Luis Salazap, which was followed by an address by Past-President Jas. Douglas, of New York city, on the low-grade copper ores of the Los Pilares mine in the Nacosari district, state of Sonora, which are owned by a company of which Mr. Douglas is the president.

Following this Mr. Manuel M. Contreras, a well-known Mexican engineer, was elected a member of the Institute, and the names of two other Mexican engineers were proposed.

Nearly every member of the party attended the reception tendered by President Diaz at the castle of Chapultepec on Wednesday afternoon. Each of the visitors was introduced by name to the President, who was assisted in the reception by the United States Ambassador, Hon. Powell Clayton.

From Chapultepec the party went by electric cars to Guadalupe to visit the Collegiate Church. A service was in progress at the time, but the visitors were welcomed by a special reception committee and were shown about the edifice. A much-prized possession of the church, a jeweled diadem of the Virgin, was brought from the vault where it is kept and exhibited to the visitors and each of the ladies was presented with a silver medal of the Virgin of Guadulupe as a souvenir.

The reception at the American Club in the evening was attended by over 500 persons and dancing continued till a late hour. So full was this day's program, in fact, that little more than half the party were able to be on hand next morning for the excursion to the great Drainage Canal at Zumpango. In fact, it has been impossible for every one to complete the full program as given above, for to do so would involve too much fatigue at this high altitude. We leave Mexico City to-night in the highest of spirits, more than delighted with our experiences.

W. K.

Pachuca, Nov. 15.

We arrived here at 7 a. m., and awoke to hear a large Mexican band playing a welcome to us. There was no more sleep for any of us, although many were worn out with the long trip yesterday to and from Cuernavaca. We had received no notice of the program for the day, and were leisurely eating our breakfast when a messenger from the local committee entered the car and told us that if we wanted to go to the Governor's reception we would have to leave at once, as he had been waiting two hours for us. We told the messenger he could wait a little longer, and proceeded to finish our breakfast, intending to do without the reception rather than do without our breakfast.

About 8.30 the last of the party straggled out to the gate of the railway station and there found about fifty of the party, who had not yet succeeded in getting carriages. All were accommodated soon, however, in vehicles of various degrees of antiquity, each drawn by either four or five mules, generally the latter, three of the mules being abreast in front and two behind them. A rapid ride over dusty streets between rows of one-story flat-roofed stone buildings, with the whole population apparently strung along the narrow sidewalks and standing in doorways to gaze at us, brought us to the palace of the Governor, to whom we were presented after a brief speech of welcome in Spanish. We were then presented by the local committee with a printed pamphlet containing a short description of the mines and mills of the district and the program for our two days' visit; but as it was all in Spanish we were not much enlightened by it.

We then re-entered our carriages and drove three or four miles out in the country and up-hill to an elevation of about 9,000 ft. over dusty roads and between large plantations of the maguey or American aloe, from which the Mexican drink, pulque, is made. The wind was high, and the dust clouds raised by our teams obscured the landscape for a quarter of a mile on the leeward side of the road. It was fortunate for us that the wind blew across the road for the greater part of the distance.

Finally we reached the Santa Gertrudis mine, which those interested in underground work went down, while the rest waited patiently above for lunch to be ready, listening meanwhile to the playing of the band.

The most remarkable sight above ground at this mine is a new Cornish pumping engine, built by Buckle & Co., Ltd., of Plymouth, England, in 1898, which is ready to run, but as yet has run only a few hours. Its steam cylinder is 90 ins. in diameter and 10 ft. stroke and its pump plunger 9 ft. stroke and 18 ins. diameter. The pump rods are 500 meters, or 1,600 ft., long. Its capacity is 1,000 English gallons per minute, or, translated into American terms, about 1,750,000 gallons in 24 hours.

This enormous engine is said to have cost over $100,000 gold. It requires a large house to contain it, and besides it requires a special steam capstan, a large drum driven through a worm-gear by a double upright engine to erect it or to remove its parts for repairs. The engine has the old Watt parallel motion and the cataract valve gear of the eighteenth century. An engine of this type has probably not been built in the United States, except possibly in California, for over 30 years, but it appears still to be built in England. The only reason for its being in this mine is that its former management was English. The present owners and managers are Mexican, and they would not have bought such an engine. Matching the engine in out-of-dateness is a new battery of Cornish boilers, but these we did not see, as they were covered over with a floor to make the boiler room into a banquet hall for our entertainment.

The mine of Santa Gertrudis is one of several famous silver mines in the district. It is developed in several levels, the lowest being 500 meters from the surface. The production since 1878 is said to approximate $25,000,000 Mexican.

After the party had become quite hungry, we were allowed to enter the dining hall, which had been made out of the boiler house, and where we found a fine assortment of things to eat and drink. Speeches were made, of course, but only one, that by the Governor, was in Spanish; the others were in English by residents of Pachuca. After leaving the mine the carriages took us back to Pachuca, where we visited the Hacienda de Guadalupe, a silver reduction works, where the old patio process, discovered here over 300 years ago, is in use. The process consists of crushing the ore, then grinding it fine in Chilian mills, washing away the fines into tanks, where the water is drained off, and conveying the remaining mud onto a flat stone pavement, where it is spread out about a foot thick, being dosed with salt, sulphate of copper and mercury. The mud lies in this shape for three or four weeks, and every day for two or three hours it is stirred up by horses or mules being driven around in it. The amalgamation of the mercury with the silver having finally taken place, the mass is washed, removing the mud and leaving the amalgam, which is roasted to obtain the silver and recover the mercury. It is stated that the process is still the best one for free milling ores in a country like Mexico, where labor is cheap and fuel dear; but experiments are now being made to improve it by substituting machine mixing for the work done by the horses and mules. It is to be hoped that they will succeed, for the process is a most barbarous one. It kills the poor animals by mercury poisoning in about six months.

W. K.

CONCRETE AND STEEL PRISON CELL CONSTRUCTION, BOSTON NAVY YARD.

Within the last year or two use has been made of concrete and steel in a number of instances for constructing prison cells. Perhaps the most recent instance of such a construction is the prison at the Charlestown Navy Yard, the construction of which is illustrated in the accompanying drawings. A similar cell construction was used at the Chelsea, Mass., police station, the cell corridor of which is shown by the half-tone engraving Fig. 1, and in the new jail at Mineola, Long Island. In all of these works the Ransome concrete and twisted steel rod system has been the one employed. The Charlestown Navy Yard prison is being built by the Aberthaw Construction Co., Boston, Mass., which owns the patents for the Ransome system in New England, and we are indebted to this company for the following description of the work:

A three-story wing of one of the stone buildings at the Charlestown Navy Yard has for the last few years been used as a prison. Sixty wooden cells have been built and fitted with iron fronts. An old cooper's furnace has been used as a dark cell. Of late the prison has become overcrowded. It was desired to alter this building into an efficient fireproof prison. The appropriation for this work was so limited that the engineer found that the cost of the usual types of cell construction ran over the amount available. His attention was called to the concrete cells, built according to the Ransome system, at the Chelsea, Mass., police station. This work, after examination by the prison authorities and by the engineer, was pronounced satisfactory and was adopted.

The work to be done consists of removing the wooden floors of the building, and constructing five double tiers of concrete cells with galleries. Each cell is in the clear 5 ft. 11-16-in. wide, 11 ft. 10 ins. long and [illegible] 9 ins. high. Two rows of 15 cells each are built back to back in each tier. The surface of walls and floors is finished in granolithic, which gives a waterproof surface.

The cell floors pitch to a drain in the gallery. The steel of the cell fronts is built in two sections for each stack of cells. The fronts for three tiers are set into place and the concrete built against them. Later fronts of two tiers are similarly placed. Anchors tie the fronts to the walls and brackets carry the gallery floor.

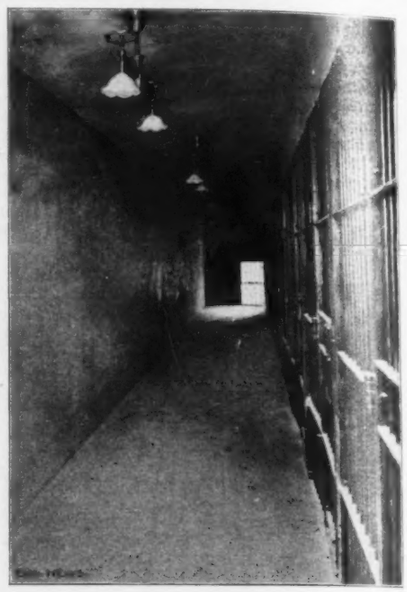

Fig. 1. Cell Corridor of Concrete and Cold-Twisted Steel Construction, Chelsea, Mass., Police Station.

All concrete work is reinforced with cold-twisted square steel bars. In the basement 16-in. concrete piers are built under the partition walls of the cells, front and back. A footing 4 ft. wide by 1 ft. thick runs continuously under each row of columns. This is reinforced with steel bars.

The first floor is a 4-in. Ransome slab covering the entire area of the building and forming the floor of the first tier of cells. From this the walls of the cells run to the floor of the second tier of cells. This floor is then laid, and the walls of second tier are started on this. This method is continued to roof of fifth tier. The walls are

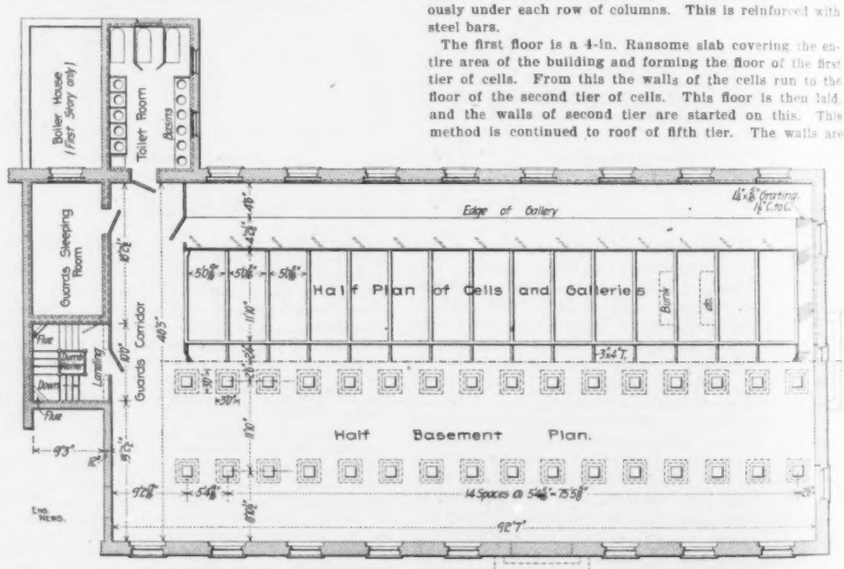

FIG. 2. PLAN OF PRISON AT CHARLESTOWN NAVY YARD, WITH CELLS OF CONCRETE AND TWISTED STEEL CONSTRUCTION.
Aberthaw Construction Co., Boston, Mass., Builders.

3½ ins. thick and are reinforced with Ransome bars. A layer of ¼-in. granolithic plastered on each face makes the total thickness 4 ins. Expansion joints are made in the floor under every other cell partition, and corresponding vertical joints are made in the rear walls. All walls are securely tied together at corners with Ransome bars. The stairs of the building are of concrete.

It is necessary to keep the prisoners in the building during the construction of the cells, and to this end only two of the old floors are to be removed until three tiers of cells are finished. The prisoners meanwhile are con-

fined in the upper story. When these tiers are complete the prisoners will be transferred to the lower cells, and the upper tiers will be built.

Referring to the illustrations, Fig. 1, as already stated, is a view lengthwise of the cell corridor at the Chelsea, Mass., police station, the grating on the right hand being the cell fronts. Fig. 2 is a plan of the prison at the Charlestown Navy Yard, and Fig. 3 is a transverse section. Fig. 4 shows

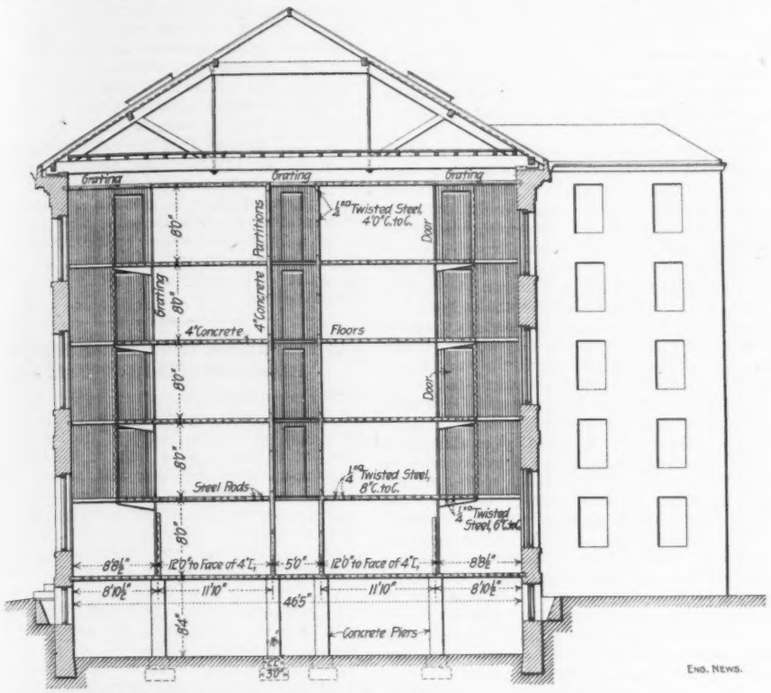

FIG. 3. TRANSVERSE SECTION OF PRISON AT CHARLESTOWN NAVY YARD, WITH CELLS OF CONCRETE AND TWISTED STEEL CONSTRUCTION.

the details of the cell front construction at the Charlestown Navy Yard. The several illustrations explain the various details mentioned quite clearly.

A NEW COMBINED WATER TANK AND COAL BOX for locomotives has been invented by Mr. Cornelius Vanderbilt. It consists of a cylindrical water tank, holding 6,000 to 7,000 gallons of water. The coal box is placed over the end of this tank, next to the cab, and the box has an inclined back, with a short section of horizontal bottom in front. In the vertical front of the box is an opening through which the fireman can easily reach the coal, which is fed to him by the inclined back. The advantages claimed for this device are greater carrying capacity of both coal and water and reduced cost of construction. The coal box holds 7 to 8 tons, and in the construction of this new tender the utilization of commercial forms of iron is made an especial feature.

NAPHTHA RESIDUE has been used in the manufacture of iron and steel for several years in Russia. This "mazout," as it is called, is a brownish black liquid remaining after the distillation of benzine and kerosene. As American petroleum produces 70 to 80% of kerosene, and the Russian petroleum only 33%, there is a much greater proportion of residue in the latter. Thus, on the average, 100 metric tons of Russian oil produce 3 tons of benzine, 35 tons of kerosene and 60 tons of mazout. This mazout contains 87% of carbon and 13% of hydrogen, and its heating power is equal to 11,000 calories, while that of coal is only 8,000 calories. The Russian engineers figure that for heating purposes 6½ tons of mazout equal 11 tons of coal of good quality. Several methods are in use for burning this fluid; the best being a modification of the Koerting injector, through which the liquid is introduced under pressure into the fire-box, through the medium of a somewhat complicated system of pipes and reheaters. Owing to the late increase in the cost of the mazout the process is only economical in the Volga region where coal is scarce and high in price. The apparatus used is described and illustrated at length in "Le Genie Civil" for Nov. 2, 1901.

THE WATER SUPPLY OF FORT WORTH, TEX., is to be increased by pumping from the city's artesian wells. The wells are 13 in number, about 1,000 ft. deep, and the water rises 35 ft. above the level of the ground. A 12-ft. pump well will be sunk to a depth of 175 ft., and from the bottom of this a tunnel will be driven to the wells, a distance of about a mile. The pumps will be at the bottom of the shaft, and are expected to give a supply of 10,000,000 gallons per day. The new works were designed by Mr. D. W. Mead, M. Am. Soc. C. E., consulting engineer, First National Bank Building, Chicago, Ill., and will be on the same general plan as the works built by him at Rockford, Ill., and described in our issue of July 13, 1899.

THE TIMBER LANDS OF THE PHILIPPINES are reported upon by a correspondent of the New York "Tribune." In these forests a timber called "belate" abounds, and table tops of it are seven to nine feet wide and made of a solid plank of this wood. It is extremely hard, beautifully veined and takes a high polish. For piling in the sea "aranga" and "dungeon" are used, as both are proof against attack by the toredo-navalis. Wooden paving blocks of "molave" have been in use six years without showing any rotting or splintering after being subjected to the heaviest traffic for this line, and to tropical sun and rains. These hard woods abound in many varieties. Other varieties yield valuable gums and rubber; and last year $300,000 worth of gutta-percha were shipped from one obscure port of Mindanao to Singapore. In answer to the criticisms on the timber wealth of the Philippines the writer says that there is no doubt of its existence, but the problem is to get it out commercially in the absence of waterways and roads. The existing waterways are full of obstructions or dry part of the year; but some of these in North Luzon and Mindanao are sufficiently deep and near valuable timber to warrant improvement. Much damage has also been done by indiscriminate native cutting, as in Central Luzon, Cebu and Negros. The forests are practically untouched, however, in the southwestern group of islands; and the Island of Mindanao, with its 23,000,000 acres, is entirely covered with valuable wood. At present prices the valuable hard woods are expensive; costing at Manila from $1.50 to $6 (Mexican) per cubic foot.

ONE OF THE CINCINNATI WATER TUNNEL CONtracts has been cancelled by the commissioners in charge of the new water-works. A difference arose, some weeks ago, over the occurrence of gas in the tunnel. The contractor refused to continue the work unless the city would assume liability for the work, and this has led to the cancellation of the contract. The contract was for 7,100 ft. of tunnel. The total length of the tunnel is about four miles. It will connect the new intake and purification works at California, O., with a pumping station in the city. Bids are wanted until Dec. 24 for completing the remaining 5,274 ft. of this section. Mr. G. Bouscaren, M. Am. Soc. C. E., is Chief Engineer of the new water-works.

THE REBUILDING OF THE AUSTIN DAM, at Austin, Tex., has been recommended by the water and light commission. No funds for carrying out the work are available and it has not yet been decided how the money could be provided.

NOTES FROM THE ENGINEERING SCHOOLS.

The Thomas S. Clarkson Memorial School of Technology, at Potsdam, N. Y., has issued invitations for its Founder's Day Exercises, to be held on Nov. 29, 1901.

THE NEW YORK UNIVERSITY has founded a new literary and scientific monthly, entitled "University Script." The late report of the Registrar shows that this university has issued a little over 10,000 degrees since its foundation, in 1831.

CORNELL UNIVERSITY. — The Richmond Locomotive Works will give to the Sibley College Museum its exhibit at the Pan-American Exposition. This consists of a full-sized locomotive and also some separate parts.

THE UNIVERSITY OF PENNSYLVANIA has acquired the large Cardeza collection of minerals, through the liberality of Mr. E. Burgess Warren. Dr. George Woodward, of Philadelphia, has given $20,000 to establish the Woodward Fellowship in Physiological Chemistry in the Pepper Laboratory.

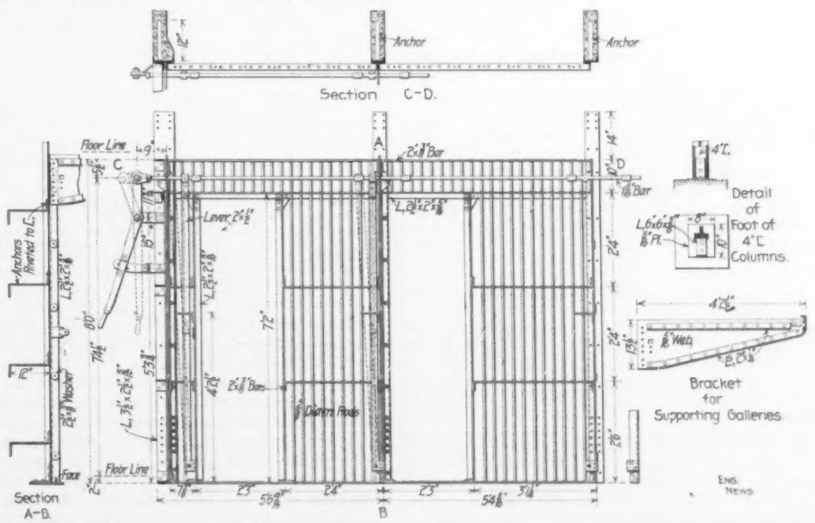

FIG. 4. DETAILS OF CELL-FRONT GRATING AND DOORS, CHARLESTOWN NAVY YARD PRISON.

UNIVERSITY OF TORONTO. — The new science building planned is to have 20,000 sq. ft. for museum purposes, which will be largely devoted to geology and mineralogy. The Ontario mineral exhibit at the Pan-American Exposition is to be used as a nucleus.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The report of the Board of Engineers on changes in design in the new Croton Dam and the Jerome Park Reservoir is printed in full elsewhere in this issue. Briefly summed up, the Board recommends that the masonry portion of the dam be extended for a considerable distance, replacing the earth dam with masonry core-wall originally adopted and now partially constructed.

The changes in the Jerome Park reservoir embankment recommended by the Board, however, merely involve slight changes in the inner slope of 2,850 ft. of embankment. No foundation exists for the newspaper statements that changes involving an expenditure of $300,000 on these Jerome reservoir embankments were recommended by the Board.

A correspondent in our issue of October 24th said:

> No one can possibly take exception to the obvious truth that all of the national engineering societies should use a union hall in which to hold annual meetings. But has any one yet shown how this can be done? Will the Civil Engineers consent to an arrangement to allow the use of their audience rooms by other engineering societies?

In comment upon the above query we stated that the New York Railroad Club held its first meeting of this season at the Civil Engineers' House and was, we understood, to use it for its meetings throughout the year.

We now learn that the New York Railroad Club is not to hold further meetings at the Civil Engineers' House. The first meeting of the season was held there, as we have stated, upon invitation of the society's officers, the understanding being that if the accommodations pleased the Railroad Club members, a lease could be given by which the club would obtain the use of the rooms for its monthly meetings throughout the year.

The club members were entirely suited and instructed its officers to close a lease for the new quarters; but at its October meeting the club was back in its old quarters at the Mechanical Engineers' House and the secretary explained the reason why as follows:

> After our last meeting held, as you all know, in the house of the American Society of Civil Engineers, the question of the expediency of that society extending to this club an invitation to hold our future meetings there was passed upon by their Board of Direction. We are now advised they deem it inexpedient to extend to us an invitation to continue to use those quarters.

"If I was so soon to be done for, what was I ever begun for?" One can only guess at the reasons which prompted the officers of the American Society of Civil Engineers first to give an invitation and then to withdraw it.

We have said, and still maintain, that so far as the membership at large of that society is concerned there would be general assent to the proposition that the auditorium in the society's house should be leased to any reputable scientific or technical society, with which favorable terms could be made, for use at any time except on the single evening in each fortnight when the society itself uses it. It appears from the above, however, that the Board of Direction of the society does not hold this view. It will follow instead the traditional policy of the past, by which the auditorium is kept religiously closed like a church, except for the three or four hours in a month when it is used for the society's own meetings.

The American Society of Mechanical Engineers has pursued what seems to us a much broader and wiser policy with respect to its house. It has leased it in past years for the use of the New York Railroad Club, the Society of Naval Architects and Marine Engineers, and the American Institute of Electrical Engineers. Its revenues from the rentals of its very small and inadequate auditorium last year were about $1,000. We see no reason why the American Society might not receive four or five times this sum from rentals of its large auditorium if it chose to make it useful in that way instead of shutting it up.

The proposed changes in the Park avenue tunnel, through which the New York Central & Hudson River and the New York, New Haven & Hartford railways enter New York city, were described in our issue of October 17, but recent developments make it extremely doubtful whether they will be carried out. As we pointed out at that time, the increase of smoke, steam and noise in the avenue which the changes would cause would make still worse the existing injury to property owners along the line of the tunnel. These property owners have now effected an organization and are combating the proposed changes before the Board of Health and in the courts.

Besides this, their counsel has discovered that under the franchise granted in 1832 the city has control of the motive power used on this portion of the railway. Section 3 of the franchise is said to read as follows:

> That the right of regulating the description of power to be used in propelling carriages on or along said railways, and the speed of the same, as well as all other power reserved to the said mayor, aldermen and commhonalty, by the act of incorporation of the said company, or any part thereof be, and the same are hereby, expressly retained and reserved.

By virtue of this clause in the franchise, an ordinance has been introduced in the Municipal Council of New York, requiring the motive power of trains moved through the Park avenue tunnel to be changed from steam to electricity, the work to begin within 60 days and to be completed within two years from the date of the ordinance.

Should the proposed ordinance pass, its validity will, we should judge, be contested by the railroad company in the courts. While the right of the city to fix the motive power to be used does, apparently, by the terms of the above quoted franchise, rest with the city authorities, their action is doubtless subject to review by the courts. They could not, for example, decree that carbonic acid gas motors should be adopted in the tunnel unless they could show that such motors were practicable for the purpose and that their adoption was demanded in the public interest and not merely to gratify a personal whim or benefit the private interests of the city officials. So in the event of the proposed change to electric power being contested in the courts, the city would doubtless have to show that the change is practicable from an engineering point of view. Whether it could do this to the satisfaction of the court remains to be seen. It would have this point in its favor, however, that the questions of first cost and cost of operation, which ordinarily weigh so largely in questions of steam vs. electric motive power, would probably be considered by the court of secondary importance. In other words, the court would doubtless hold that the city's authority to order the change of motive power should not be interfered with, even though the change might involve several million dollars loss to the railway companies.

It must be said that the railway company has deliberately brought its present predicament (with the chances of a worse one) upon its own head by its failure to provide a proper ventilation system for the tunnel years ago. Had it spent a hundred thousand or so on such a system before the present agitation began, it would have saved itself probably a vastly larger expenditure in the future.

HAS THE INCREASE IN WEIGHT OF FREIGHT TRAINS AND LOCOMOTIVES REACHED ITS LIMIT?

The most important feature in the development of railway transportation in America during the last quarter century has been the increase in the size of freight trains and of locomotives. To this, more than anything else, is due the great reduction in the cost of moving through freight and the accompanying fall in freight rates which has taken place. To keep pace with this development the permanent way of our railway lines has had to be rebuilt again and again. The 40 or 50 lb. iron rails of the '60's gave way to the 70-lb. steel rail, and this in turn to the 90-lb. and 100-lb. rail. Bridges have been strengthened and renewed, grades have been cut down, and yards have been enlarged to accommodate the very long trains which the traffic department has put on the road.

Twenty-five years ago the "American" type locomotive was in so nearly universal use for both freight and passenger service in the United States that its name was well justified. In those days 60,000 lbs. was a fair weight for a locomotive, of which about 40,000 lbs. was on the driving wheels and available for traction. For an example of a typical present day locomotive to contrast with these, we may take some heavy consolidation engines recently built by the American Locomotive Co. for the Delaware, Lackawanna & Western R. R. From a description of these engines by Mr. F. J. Cole at the last meeting of the New York Railroad Club we find that their total weight is 178,000 lbs., of which 157,500 lbs. is on the drivers. Measured by adhesion, therefore, the tractive power of such a machine is about four times that of the typical locomotive of 1876.

It is a question of great interest how much further this movement toward heavier trains and locomotives is to extend. Will the railways of 1926 haul 5,000-ton trains with 250-ton locomotives? One might easily judge this to be probable if the past were taken as an index of the future, but there have been developments of late which indicate that the economical size for locomotives has finally been reached and even exceeded in some cases.

Many of our readers will recall, we are sure, the illustration and description in this journal two years ago of a couple of locomotives for the Illinois Central R. R., which were at the time of their construction the largest in the world and have been excelled since only by the huge engines built at the Pittsburg Locomotive Works for the Pittsburg, Bessemer & Lake Erie R. R. The largest of these Illinois Central engines weighed 232,200 lbs., of which 193,200 lbs. was on the drivers. At the September meeting of the Central Railway Club, in the course of a discussion on "Double-heading with the heavy type of Engine," Mr. Sullivan, of the Illinois Central, gave the following interesting account of the results obtained with these huge locomotives in service:

> The Illinois Central two years ago had built what were then the two largest locomotives in existence. They were

simple engines, with cylinders 23 × 30 ins., they carried 210 lbs. of steam, had 82-in. boilers, long fireboxes, one a consolidation, the other a 12-wheel type. We were quite interested to know what this size of engine could do in the way of ultimate pulling capacity, so the order was given to start with a train of 1,500 tons on a run out of Chicago of about 50 miles, in the middle of which was the ruling grade of that district, about 24 ft. to the mile; and each day it made the trip increasing the train-load by 500 tons until the train got up to 3,500 tons—82 loaded cars. There was no trouble in the engine handling the train; the trouble was to handle the engine.

We had two engineers and three firemen; that is, we had three men in reserve, and when we came to the heavy part of the hill the engine in its hardest pull made a mile and a half to a ton of coal, and used up 5,000 gallons of water in running five miles. When it arrived at the station at the summit of the grade it had to cross over to the other track to let an important passenger train pass it, necessitating a short back-up movement to enter the cross-over track. In making this back and forward movement the train broke in two, eight or nine different times, on one occasion shearing under the head and under the nut 12 1-in. drawbar pocket bolts, so great was the power of the engine. Two hours and three-quarters was consumed in crossing over and getting back, and the train that it was intended to let by without causing any delay, was delayed an hour and a half

We came to the conclusion that it was quite possible to get one engine that was large enough to handle a bigger train than was practicable, as a transportation proposition, to move over the road.

These large engines have now been in service nearly two years. We give them each trains of 1,800 tons on portions of the road where mogul engines of 19 × 26-in. cylinders handle trains of 900 tons. Each of the big engines takes a double train. The total expense of moving 10,000 tons one mile with the big engines is $1.86, as against $2.02 with the mogul. By reducing the train to a tonnage that could be handled readily, we have been able to operate the large engines successfully, having them take their turn in the service just as it comes—one day with a heavy coal train, next day with a stock train, or with a banana train, making speeds anywhere up to 45 or 50 miles an hour, and do that without any trouble. We think that such an engine is, if anything, larger than economical locomotive practice demands, and have purchased no more of them. We find that a mogul engine with 20 × 28-in. cylinders, carrying 200 lbs. steam pressure, will take the same train over the road just as well as the engine with 23 × 30-in. cylinders. In other words, the 80-ton engine will do the work just as well as the engine which weighs 110 tons, and either of them will do better than a double-header.

It will be evident from the above that in this case at least the economic limit to the size of trains and of locomotives has been reached and passed. Further, there is good reason to believe that this is not an isolated case by any means, but that a good deal of experience has accumulated within the past few years indicating that freight trains of extraordinary size, while they may show a nominal reduction in the cost of train service, are in the long run more costly than lighter trains. To state a fixed limit for economic size of freight train applicable to all roads alike is of course out of the question since conditions vary so greatly. It may be said, however, that a freight train of 2,000 tons appears to be about the limit which has thus far been found economically profitable, and trains of this weight can be successfully run only on a very few roads, where grades, character of traffic, rolling stock and facilities at hand are favorable.

Probably the most important factor at present in fixing a limit to train lengths is the strength of draft gear and couplings, and we may add strength of car bodies as well. It is not generally realized how the old light-capacity freight cars have been driven out of service by the recent heavy cars of 60,000 to 100,000 lbs. capacity. In the Central Railway Club discussion above referred to, the committee reporting on the handling of very heavy trains recommended that the train be made up with the heavy capacity cars next the engine and the light capacity cars in the rear. We may quote the comments of Mr. Sullivan on this proposition as follows:

From a transportation point of view such an arrangement is not practicable, except in yards where trains are made up and then only on through trains that will run over a district or division without having to do any way work. But it is not often that trains can be so run, for while they may not have any local work to do, there is always more or less interchange business at junctions with other roads that has to go forward in through trains, so that on very long trains, with light capacity cars on behind, it becomes very slow and risky work to switch from the rear end. On many schedules where time is short, cars have to be switched into the train just as they come and take the chances of the light cars being able to stand the stress of the service. A great many of them are not doing that. The road I am connected with faced that question by deliberately destroying a great many of its light cars. I recollect one year that we burned up 2,000 box cars of 15 tons capacity in order to get them out of the way. We couldn't stand it having them breaking down and collapsing and endangering all the other cars in the train; the risk was too great; and we figured it out that it was an economical proposition to dispose of them in that way.

But the 50,000-lb. and 60,000-lb. wooden cars when coupled up to the 100,000-lb. steel cars in long trains are about where the old 10-ton and 15-ton cars were when the 30-ton cars came in. Is it going to be worth while to send these also to the scrap-heap for the sake of hauling still heavier trains? We do not believe it. When a freight train reaches 2,000 tons in size there is not much to be gained either in economy in train service or capacity of the road to handle traffic by increasing its size. The large locomotives of the present day are up to the limit of what one man can fire; still longer trains and heavier locomotives would mean a locomotive crew of three men instead of two and probably an extra brakeman as well. Further, the extra care which must be taken in starting, stopping and handling trains of greater size than the above-named limit, the extra time required to make up in the yards, the liability to delay by minor accidents, the slower speed which is practicable, the greater clear headway which must be allowed—these are a few of the many things which make such trains not only more expensive in operation, but less efficient in the movement of traffic in a given time than trains of smaller size.

It may be said, however, that all this applies only to present day conditions. When the steel car replaces the wooden car, when draft rigging and couplers are improved, and brakes are better maintained, will it then not be worth while to again largely increase the size of locomotives and of freight trains over the standards of the present day?

Some advance in this direction there doubtless will be, but it will be trifling, probably, compared with the changes that the past quarter century has seen. No matter what changes the future may bring, two dimensions of the railway as a machine are fixed and incapable of enlargement. These are the gage of the track and the clearance space fixed by tunnels, etc. These compel the increase in size of trains to be made only by increasing the length, and difficulties thicken in various directions when the length of trains exceeds a certain amount.

It must be borne in mind, too, that in considering the economic movement of freight a broad view must be taken and the needs of the local lines and branch roads must be considered as well as the needs of the roads handling traffic of enormous volume over long distances. Three-fourths or more of the railway mileage of the country never sees a through freight train, and furnishes no more traffic than trains and locomotives of moderate size can readily handle. Any change in rolling stock or operating conditions which operates against roads of this class might prove a loss to the railways as a whole even if it were a benefit to the lines hauling heavy traffic.

LETTERS TO THE EDITOR.

The Proposed Increase of Dues in the American Society of Mechanical Engineers.

Sir: The article on "Increase of Dues in the Am. Soc. M. E.," which I find in to-day's Engineering News, is first-class. It shows up the whole matter clearly to busy members and is very convincing. All the members ought to appreciate it. Yours truly,

H. P. Quick.

439 Albany St., Boston, Mass., Nov. 22, 1901.

Sir: I am in receipt of the circulars concerning the proposed increase of dues in the American Society of Mechanical Engineers.

While under the constitution I am not entitled to a formal vote, yet I desire to record my protest against the proposed increase, in the hope that some voting members, feeling that they are acting as the representatives of the non-voting members, may consider the wishes of their constituents and vote accordingly.

I have studied the circulars carefully and fail to find in them a sufficient reason for such an important step, nor is it at all clear to me what is to be done with the additional $20,000 income which this increase of dues would produce. The arguments against the policy of "research and investigation" are so ably set forth in Engineering News of Nov. 21, that it would be an impertinence for me to add a word of discussion. I can only commend the entire article to the earnest attention of those who are to vote on this question.

In the sixth paragraph of the circular of Sept. 21 we are told that "some provision for more satisfactory housing of the Society and its library must be considered before long," but on the second page of the circular of Nov. 6 it is deemed "further desirable to say that the question of the increase in the dues is practically independent. . . . of any question affecting the headquarters of the Society and the accommodation of its library." Obviously, then, it is not for a new house that the money is wanted. Are we to have another increase when the house question does come up?

"A year ago the Council's annual financial report showed a surplus . . . of about $1,850" (I quote again from Engineering News of the above-mentioned date). What then has caused such an increase of expenditure that the Society should now be in debt to its printer as we are told in paragraph 1 of the summary in the second circular?

It occurs to me that, taking them as a whole, the members of the Society receive rather more information than knowledge in the various different circulars, bulletins, etc., issued from the Secretary's office. Might I suggest that since the unconstitutionality of the letter ballot was recognized at the time of the issue of the first circular, the proxies for the voters could have been sent out at that time and the cost of the issue of the second circular saved to reduce the printer's bill?

It also seems to me that since the papers to be presented at the meetings of the Society are printed in full and issued to the members some little time before the meeting, the issue of an abstract of the papers to be presented is of rather doubtful benefit as it does not need to be proved that a paper of any kind can be better discussed after it is read than before.

Finally, as to the actual amount of the increase. While it is true that the cost per day is a very small sum, yet that amount added to the present dues makes the total approach dangerously near to and in many cases past the sum that the average practicing engineer, Member, Associate and Junior alike, can afford; and this is especially true in the case of new members of all grades when the increase added to the present dues and initiation fee make an amount that, to pay all at once, might cause considerable embarrassment.

For the above reasons, therefore, I think an increase of dues at this time very unwise, and hope that a majority of the voting membership will consider that it is for the best interests of the Society that the increase should be defeated. Very respectfully yours,

A. L. Brodhead, Jun. Am. Soc. M. E.

Stewartsville, N. J., Nov. 23, 1901.

Temperature Stresses in the Stiffening Trusses of Suspension Bridges.

Sir: My observations on the Brooklyn Bridge (Eng. News, Oct. 24, 1901) and on their report on its conditions has led Engineers Duryea and Mayer to discuss some of the points to which I had called attention (Eng. News, Nov. 7, 1901).

Among them is the question of temperature stresses in stiffening trusses, more particularly in three hinged ones. It is not a vital question affecting the safety of the Brooklyn Bridge, and it would hardly deserve further comment in that connection.

But in an investigation intended to be reliable, as no doubt the two engineers wished it to be, the practical conclusions reached, and the recommendations based thereon, derive much of their value from the theoretical methods used. Let us look a little closer into one of these methods produced by Mr. Mayer, that on temperature stresses.

That there are large temperature stresses in three-hinged stiffening trusses was first stated by the writer in 1888 (Engineering News, March 10, 1888), and again in a paper in 1894 (Appendix D of the Report of Engineer Officers, published in Engineering News, Nov. 22, 1894). Mr. Mayer says he has consulted it and has found that it gives greatly exaggerated results.

Parenthetically I may mention, that at the writer's suggestion, Professor Melan,* of the Polytechnical School in Brünn, in Austria (who requires no introduction to bridge engineers as a mathematical analyst of a high order, and who is a very good engineer besides), has made an independent and closer investigation of the problem. His results are published in an article in the

*Professor Melan's theory of the stiffening truss has been translated and forms Appendix E of the same Report of Engineer Officers, published Eng. News, Nov. 22 and 29, 1894.

considerations were doubtless predominant. It has been abundantly proven that up to a height of 60 ft. or 70 ft. an embankment founded on solid material and constructed of well-selected earth, properly put in place, is fully as durable and safe as a masonry wall and far less costly. In this case the foundation is the natural hillside of compact glacial drift.

The design of this embankment is that which has been followed in all the earthen dams constructed in the Croton valley for the past 30 years. In the center of the bank is built a wall of rubble masonry, generally founded on the solid rock, and intended to prevent the free passage of water, but not heavy enough to act alone as a retaining wall for either water or earth. It is endeavored to make this wall water tight, but in most cases such efforts have not been entirely successful. On each side of this wall is built an embankment of selected earth free from large stones, laid in thin horizontal layers, wet and compacted by carting over, ramming and rolling with heavy grooved rollers.

On the side towards the reservoir, the slope of the bank is paved with stone, the slope of the outer bank is sodded. This is the latest accepted engineering practice in this part of the country for the construction of earthen dams of moderate height to retain the water of reservoirs. The variations which occur in construction are in the steepness of the slopes, the character of the paving of the water slopes, and the methods of compacting the material as it is put in place. The plans and specifications for this work are carefully drawn and the material to be used is of such character as to make it certain that if constructed under proper supervision the 300 ft. of the dam from the southerly end will be safe beyond peradventure.

The remaining 150 ft., comprising the junction between the masonry dam and the earthen embankement, presents, however, a different problem. The structure at this point is unlike any existing earthen embankment of which we have knowledge. In order to enable the masonry dam to be founded, a pit (see Fig. 1—Ed.) was excavated to 150 ft. below the surface of the ground and 160 ft. wide at the bottom. The sides of this excavation slope outward and upward so that at the surface of the ground the pit at one end is 30 ft. deep, 20 ft. wide at the bottom and 110 ft. wide at the top; and at the other end, where the masonry wall begins, the pit is 135 ft. deep, 160 ft. wide at the bottom and 560 ft. wide at the top, and this end is open to the valley. The bottom of this pit is 60 ft. below the bottom of the proposed reservoir.

After filling this pit to the level of the bottom of the reservoir, it is necessary, in order to make the connection between the masonry and earthen sections of the dam, to construct in it an embankment, which at one end is 70 ft. high, and is 20 ft. wide at bottom, 110 ft. wide at 30 ft. above the bottom, then widens out to 206 ft., and is then drawn in to 46 ft. wide at the top. At 75 ft. from the end, it is 100 ft. high, 50 ft. wide at the bottom, 403 ft. wide at 40 ft. above the bottom and 46 ft. wide at top. At the northern end it is 150 ft. high, 250 ft. wide at the bottom, 560 ft. wide at 80 ft. above the bottom and 46 ft. wide at the top.

This end abuts against a masonry wall 150 ft. wide, and the portion of the bank which extends beyond the masonry height of 40 ft. at the south end and 70 ft. at the north end.

There is no earthern dam of equal magnitude in existence (see Fig. 2—Ed.), so far as we can learn, and there are, therefore, no precedents to guide us in forming an opinion as to whether such a structure can be made safe.

As regards the stability of such a structure against overturning or sliding on its base, no question can exist.

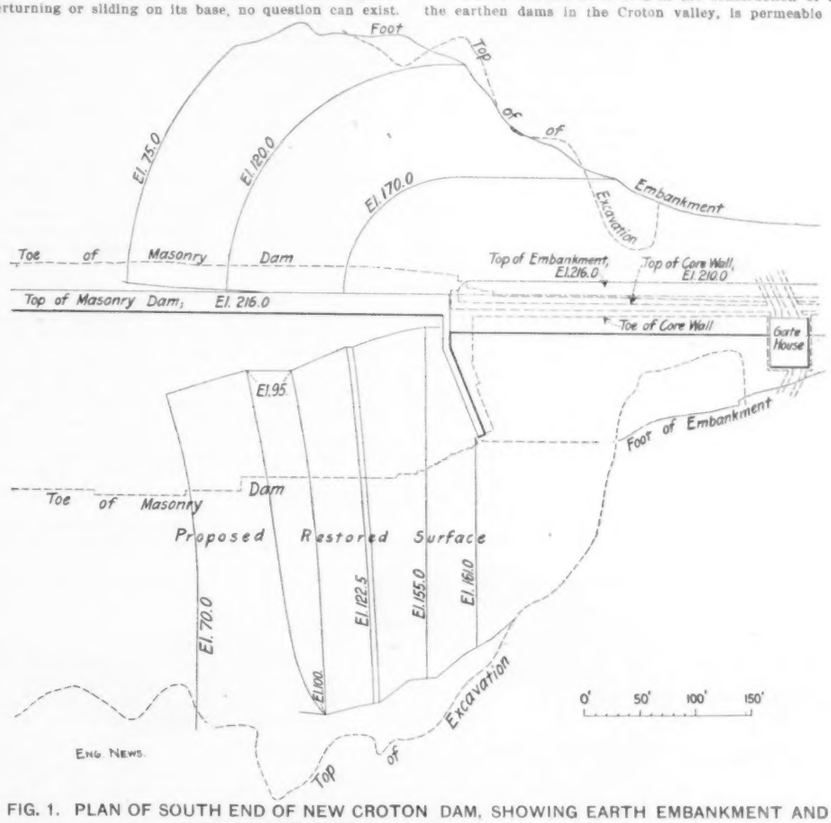


FIG. 1. PLAN OF SOUTH END OF NEW CROTON DAM, SHOWING EARTH EMBANKMENT AND JUNCTION OF SAME WITH MASONRY STRUCTURE.

The point to be considered is whether an earthen dam like this can be made sufficiently impermeable to water to prevent the outer slope from becoming saturated and thus liable to be washed out and slide.

Whether such a result can be accomplished depends largely upon the character of the material employed in the construction of the bank. We examined the material which has been used in the building of the embankments so far constructed and we made some experiments on the permeability of the material when placed in embankment and when subjected to the action of water. We also procured several samples of material taken from the embankments and from pits in the vicinity, giving a fair idea of the nature of the materials which have been and which may be used in the banks, and had tests of them made by the hydraulic laboratory of Cornell University. The results of these experiments and tests are given in full in the appendix to this report. (Fig. 3, illustrating the probable saturated portion of the New Croton Dam is reproduced here—Ed.) All the tests indicated that this material, which we found to be almost identical in character with that which has been used in the construction of all the earthen dams in the Croton valley, is permeable to water under any head from 3 to 150 ft., and that when exposed to the direct action of water it disintegrates and assumes a flat slope, the surface of which is best described as slimy.

On examining the face of excavations which have been made in various parts of the Croton valley, we observed that the materials composing the glacial drift are not, as a general rule, evenly distributed or intermingled so as to form a homogeneous mass. There are distinct masses of gravel and boulders, beds of sand and finer gravel, and large pockets of a very fine sand with a small amount of clay, forming a very compact material when not exposed to the action of water, but dissolving readily and becoming quite fluid when water reaches it. On inspecting the hillsides along the valley of the river above the

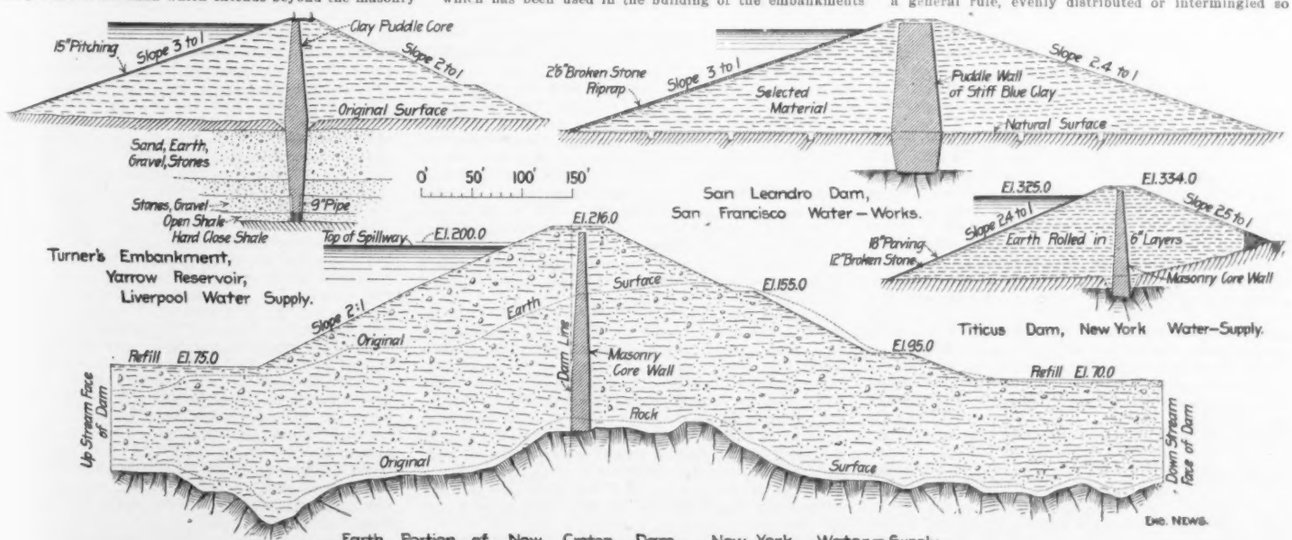


FIG. 2. COMPARATIVE CROSS-SECTIONS OF THE HIGH EARTH DAMS OF THE WORLD.

(The section of the New Croton Dam is a developed section "on the line of least resistance to the passage of water normal to the slopes of the embankment.")

on each side has to be supported by a sloping embankment extending down the face of the masonry dam 300 ft. on the upper side and 200 ft. on the lower side. These supporting banks are conical in form, the base being carried around to meet the natural surface of the ground above and below the dam. This embankment is built up above the original natural surface of the ground to a

"Zeitschrift des Osterr Ingenieur und Architecten Vereins," Sept. 7, 1900 (with all rights reserved), and to which also I had called Mr. Mayer's attention.

Professor Melan adopts the same reasoning as the writer, on the unequal distribution of dead load caused by the changes in the cable deflections, and agrees with him, that an accurate treatment of the problem, although not impossible, would be very difficult and laborious. Using a higher degree of approximation, his results do not differ materially from those of the writer. Briefly stated, they are that for deflections of the cable, caused by temperature changes alone, the bending moments in the three-hinged trusses are nearly the same as those of trusses without a center hinge.

For deflections of cable caused solely by full uniform live loads, Professor Melan finds the stresses in the three-hinged trusses about 30% greater than for trusses without a center hinge. The maxima from the above-named causes occur for three-hinged trusses at the quarters and for truss without middle hinge at the center of the span. The temperature stresses are large, certain and frequent, and cannot be neglected. For high trusses they can become greater than the live-load stresses. Therefore their importance.

In all such investigations the trusses are correctly assumed to be freely suspended in space from the cable resting on the towers. The cable carries the whole load. At the center the truss ends are connected with each other, but the other ends are free. They only touch on the towers. It requires no proof, that under these conditions, the total load on the cable is not changed (either diminished or increased) by temperature changes. Its distribution on the cable is, however, certainly changed. There can be no vertical reactions either up or down at the ends of stiffening trusses from that cause, nor from a uniformly distributed live load.

The deflection from those causes of the cable and the truss up or down, and the resulting stresses in same, are precisely the same as if the truss ends in the towers were free in the air. That also requires no proof, and therefore it is the accepted method for the theoretical treatment of the question.

End hinges to prevent the lifting of the truss ends are required only for unequally distributed live load.

The changes of length in the suspenders from temperature or live loads are usually neglected in such investigations. They do not essentially influence the results one way or the other. If necessary, allowance for them can be made afterwards.

Mr. Mayer's method also neglects the changes in the suspender lengths, and he further and improperly neglects the deformation of the truss, caused by the rise and fall of the cable.

It is the deformation of the truss and its resistance to bending, however, which begs the whole question. How often must it be pointed out, that in a stiffening truss everything is determined by deflections, and that they determine the sections!

If we can define the law of its deformation and that of the cable, we can from it find the stresses in the truss. As that law has not been determined yet with accuracy (because, as stated before, of the great mathematical difficulties and of the labor involved, and if found might be of little practical use to engineers) we get along with approximations. We know that they give us results close enough and on the safe side of academical truth. That applies to all kinds of stiffening trusses, end hinged, three hinged, and those continuous over the span and through the towers.

Mr. Mayer's method for three-hinged trusses gets around that difficulty in a simple way. He ignores their deformation and assumes vertical reactions at their ends in the towers and at the center hinge for any change from the middle temperature, for which alone he has no reaction. When the cable drops, a part of the dead load, Mr. Mayer says, is carried by each half truss to the tower end and another part to the center hinge. The trusses turn here around the hinge, and the cable forms a kink downward, trying to assume as it were the inverted form of a flat Gothic arch. The cable is relieved of a part of its load, which goes through the stiffening trusses to the towers. No proof is furnished by Mr. Mayer for that distribution of load.

Conversely it must be true, although Mr. Mayer neglects to say so, that on rising of the cable during cold weather, the half trusses turn around the center hinge upward. The end of each half truss in the tower will need to be held down and the other ends at the center hinge will force the cable up, as formerly they forced it down. It forms again a peak or kink, but upward this time. Moreover, the load on the cable is increased by the amount of weight or force necessary to hold down the ends of the half trusses in the towers.

Having in that way settled in advance the law according to which truss and cable act, Mr. Mayer has, of course, no difficulty in proving the rest. It becomes then an elementary geometrical proposition.

Equating the load conditions for the preconceived relations of cable to truss, it follows naturally that the half cables are still of the parabolic order, and "that the suspender pulls, though they are changed from what they were by the drop (or rise) of the cable, are still constant over the whole length of the span" (except at the center hinge, where the suspender must take tension and compression alternatively not mentioned by Mr. Mayer).

Taking moments, and setting up the equation for equilibrium of forces, Mr. Mayer finally finds the load T per lineal foot of bridge "which would produce the same stress in stiffening truss as a rise (or fall) of temperature."

$$T = \frac{2S}{l} = \frac{8(w+q)L^2}{h\,l^2}.*$$

Making L (span, c. to c. of towers) = l (span of stiffening truss) we have simply

$$T = \frac{\delta(w+q)}{h}$$

This expression, it will be observed, is independent of the truss and its resistance to bending. It means that a low truss will relieve the load on the cable (or respectively add to it) the same proportion of dead load as a high truss. For the same load, chord stresses in high trusses are lower than in low ones, inversely as the heights. From which it follows, according to Mr. Mayer, that the temperature stresses are lower in high stiffening trusses than in low ones.

If that is the correct law, it must hold also when the height of the stiffening truss becomes zero, that is when there is no stiffening truss. But we find then that the cable is still relieved by (or has added to it) the same load T per lineal foot of bridge. The chord sections become then infinite; the weight of the truss, and upon the cables and of the cables themselves, is also infinite, likewise the weight on the towers and anchorages. In other words, the correct theory of Mr. Mayer is nonsense by his own proof.

One other point the writer would like to correct. Messrs. Duryea and Mayer say: "Mr. Lindenthal thinks 17 ft. deep stiffening trusses with a stay system are too flexible." Please note that I had not said so and had not expressed an opinion on the height of stiffening trusses, their number or their flexibility, that would justify that statement or inference.

As regards some of the other questions in connection with their recommendations discussed by Messrs. Duryea and Mayer, I confess that their arguments do not seem to me convincing. The subject would certainly require more study.

Gustav Lindenthal.

45 Cedar St., New York, Nov. 13, 1901.

THE BIDS FOR 11,004 WATER METERS, received at Cleveland, O., on Nov. 20, are given in detail in the Supplement to this issue. The lowest bidders on the various sizes were as follows: 10,000 ⅝-in. meters, $6.10 each; the Union Meter Co., of Worcester, Mass.; 800 ¾-in. meters, $9.60, the Permanent Mfg. Co., Cleveland, O.; 200 1-in. meters, $13.26, Hersey Mfg. Co., South Boston, Mass.; 4 6-in. meters, $265, Pittsburg Meter Co., East Pittsburg, Pa. Mr. E. W. Bemis is superintendent of water-works.

THE INTERNATIONAL CORRESPONDENCE SCHOOL of Scranton, Pa., celebrated its 10th anniversary on Oct. 16 last. The first student enrolled in 1891 was Mr. Thomas Coates, of Peckville, Pa., and the teaching staff then numbered eight or nine persons. To perform the work of the school a staff of 2,500 persons is now required, and up to the present time 341,500 students have been enrolled. About $100,000 per annum is paid in postage; the school printing office employs 132 people at Scranton, and in addition two large printing offices in New York are largely supported by the work done for the school. They distribute 24,000,000 pages of advertising matter per month. The largest private printing and binding plant in the world is now being constructed at Scranton; it will have a capacity sufficient to print, fold and bind 2,000 400-page 6 by 9-in. volumes per day, and the buildings will contain 6¼ acres of floor space. In 1898 an instruction-car was built for the purpose of soliciting business from and instructing railway men. Six of these cars, thoroughly equipped with models, etc., now traverse nearly every railway in the country, and are instructing over 15,000 railway employees in matters pertaining to their business.

MORE STRINGENT REQUIREMENTS for admission to German technical colleges are urged by the most important German engineering society, the Verein Deutscher Ingenieure. This society has recently made a demand upon the trustees or governing faculties of all technical schools in Germany for unity of action in at once raising the requirements for admission. It is especially urged that admission to the undergraduate courses in mechanical and electrical engineering and naval architecture be further conditioned on the completion of a year's work in the shop and admission to graduate courses on three years' work in the shop. It is also demanded that admission requirements be placed at least as high for foreigners as for native students.

THE INTERNATIONAL MARITIME ASSOCIATION has been organized, as an outcome of the International Maritime Congress, held at Monaco in April, 1900; its headquarters are at 3 Rue des Mathurins, Paris. Its purpose is the promotion of general progress in navigation and maritime commerce by attempting to solve many questions of an international character; and to [illegible] the problems of marine signals, sea-worthiness of vessels, uniform rating of vessels, steamer routes, warning of approaching storms, notice of dangers to navigation, uniform system of buoys and beacons, night signals, etc. It would work through international congresses and publication of proceedings. Mr. T. Charles-Roux is the first President.

*For meaning of letters, see Engineering News, Nov. 7, 1901.

REPORT RECOMMENDING CHANGES IN THE NEW CROTON DAM AND JEROME PARK RESERVOIR.*

As requested by you, in your resolution of June 27, 1901, the undersigned have examined the present plans for the construction of that portion of the New Croton Dam on Croton River, at Cornell site, which is designed to be constructed of earth, with a masonry core-wall, and the work of construction thereof, as far as the same has proceeded, and also the core-wall and embankments of the Jerome Park Reservoir. We have the honor to report thereon as follows:

THE NEW CROTON DAM.

This dam is built across the valley of the Croton River, from north to south, about three miles from the Hudson River. At this point the channel of the river runs near the foot of the north bluff, which rose 150 ft. in a distance of 350 ft. The face of this bluff was excavated to solid rock and a masonry wall about 1,000 ft. long was built parallel to the course of the river, with its coping for 750 ft. at the elevation of 200 ft. above the level of mean tide water of the Hudson River, or 150 ft. above the river channel, and for 250 ft. at the elevation of 196 ft., forming a spillway for the water which may overflow the dam in freshets. On this portion it is proposed to place flash-boards 4 ft. high, making the elevation of the water surface ordinarily 200 ft. above tide level. On the line of the dam the channel for the water is over a solid masonry wall about 200 ft. long at top, abutting against the rock of the hillside at the northern end, and at the southern end against a tower of masonry, in which are placed gates for emptying the reservoir if necessary, the sills being at the elevation of 100 ft. above tide.

The bottom of the valley is nearly level south of the river for 400 ft., and the hillside then rises 100 ft. in 300 ft. and then 70 ft. in 400 ft. more to the elevation of 220 ft. above tide level.

From the wasteway to the point on the hill on the south side of the valley where the surface of the ground was 110 ft. above the channel of the stream, a distance of 735 ft., the dam is designed to be built of solid masonry with cut-stone faces, from the original surface of the ground to the elevation of 210 ft. above tide level, or 10 ft. above the proposed full-water surface of the reservoir. Below the original surface in the valley, the earth and rock have been excavated to a depth of from 120 ft. to 160 ft., until solid rock was reached. This pit was filled with rubble masonry, which at the lowest point is 216 ft. wide and at the stream level is 120 ft. wide and forms the foundation of the dam, the width of which is gradually diminished in accordance with the latest theories of masonry-dam construction, until at the full-water elevation of the reservoir it is 19.2 ft. wide.

In the original plans, it was provided that this masonry dam should be 625 ft. long, but on Sept. 16, 1896, it was determined to extend the masonry 110 ft. further into the hillside, to its present location, where the solid-rock foundation and the natural surface of the hillside are respectively 45 ft. and 50 ft. higher than at the original location. This change was recommended by the chief engineer, Mr. Alphonse Fteley, from his "present knowledge of the foundation and the experience gained from the erection of high embankments in connection with other dams" in the Croton valley.

At this point, the solid masonry dam terminates abruptly, being there 195 ft. high, with a bottom width of 160 ft. At the end, the masonry is built up square, and 150 ft. wide. From this point to the southerly end of the dam, a distance of 454 ft., the present partially-executed plans provide that the dam shall consists of an earthen embankment 46 ft. wide at the top, with side slopes of two horizontal to one vertical, and having on its center line a wall of rubble masonry built up from the solid rock, 6 ft. wide on top and increasing in width until at and below 150 ft. from the top it is 18 ft. wide. The slope of the embankment inside of the reservoir is to be covered with a layer of broken stone, on which will be laid a heavy block stone paving. The slope on the down stream side will be sodded.

You ask us to consider the plans for the construction of this earthen portion of the dam, the work thus far done in building it, and whether any changes or modifications should in our opinion be made in the plans.

THE EARTHEN EMBANKMENT.—In determining the plan of construction for this part of the dam, financial

*Submitted to the Croton Aqueduct Commissioners on Nov. 18, by Messrs. J. James R. Croes, New York city; Edwin F. Smith, Philadelphia, and Elnathan Sweet, Albany, N. Y., Members of the American Society of Civil Engineers. The report is followed by a statement relating to the matters covered by the report, signed by Mr. Sweet.

above the natural surface, might be made an earth embankment. The additional expenditure required to change the 200 ft. between the gatehouse and the present end of the masonry dam from earth to masonry would be about $[illegible]000.

So far we have only consider the plans of this structure from an engineering point of view, that is to say, as regards the building of a structure which shall be reasonably secure against ordinary contingencies, at the least cost. There should, however, be precautions taken against extraordinary contingencies.

One such contingency which might arise is the occurrence of an extremely heavy rainstorm or cloudburst in the Croton valley, or the failure of one of the large dams farther up the valley, which might bring down a volume of water which the wasteway of the dam would be unable to carry off as rapidly as it came, and the dam would be overtopped, in which case the earthen embankment as at present planned, with the top at the same elevation as the top of the masonry dam, would be carried away. In the original designs of the dam, it was proposed to build the masonry portion of it to the elevation of 216 ft. above tide, or 10 ft. above the ordinary high-water level of the reservoir, and the earthen embankment was to be built 10 ft. higher, so that a wave of translation induced by a heavy landslide, the failure of a dam further up the stream, or a cloudburst, and which might easily rise to the top of the masonry, would have a vent over the masonry and not rise to the top of the earth embankment. It is true that the original plans, as shown on the drawings accompanying the contract, were defective in their provision against such a contingency, here the most stupendous masonry structure of its class in the world. For nearly 1,000 ft. of its length, no criticism as to its stability and permanency can be made. Then, solely from economical considerations, the design and the character of the structure are changed for a length of about 450 ft. This portion of the structure would not present an insignificant appearance in comparison with the main portion of the dam, if built in harmony with it, for it is, in itself, as it would appear above the surface, a higher and larger dam than any except a very few dams which exist elsewhere. The impression produced on the beholder by the present plan is that of a parsimonious makeshift not in harmony with the central portion of the dam nor with the massive spillway at the northern end, and would lead the general observer to inquire why so great an expenditure had been made on the ornamentation and architectural appearance of the central portion of the dam, instead of being applied to the creation of a massive homogeneous structure for the whole length of the dam, producing an impression of durability and stability which a composite arrangement of the kind proposed by either the original or the present plans does not inspire.

In our opinion, the absolute security of the dam against disaster, the architectural and aesthetic harmony of the structure, and the general feeling of security in the public mind, would be satisfied only by the substitution of a masonry structure, similar in design to the rest of the dam, for the earthen bank proposed by the present plans.

We therefore recommend that the plan of construction of the southerly end of the New Croton Dam, from the end of the present masonry dam to the gatehouse con-

that for the section of the reservoir embankment to which you have called our attention, extending across the south end of the reservoir and along its east side, a total distance of 2,850 ft., a core-wall has been built, of which over 1,200 lin. ft. are founded on earth and the remainder on rock.

The profile of the rock surface under the entire length of this core-wall is very irregular and is overlaid with a stratum of sand, the upper surface of which is approximately horizontal and about 20 ft. below the top of the core-wall masonry, and extends thence down to the surface of the rock.

The question at issue is whether it is essential to the stability of the embankment and the security of the reservoir against dangerous leaks that these walls should in all cases be founded on the underlying rock.

The reservoir is evidently in a basin of the rock surface, surrounded by a ridge of rock, in which there are apparently some depressions through which water may drain to the north, the south and the east. The largest and most important of these depressions is at the north end of the reservoir. To this our attention has not been called.

At the south end, adjacent to the Kings Bridge Road, at or near Station 76, there is an evident depression in the rock barrier, extending 20 ft. below the bottom of the reservoir. The borings made indicate that this depression is filled with a fine sand which is saturated with water, is stable when confined, and cannot run unless exposed to flowing water with a free outlet.

Under the embankment, this depression is about 300 ft. wide and the core-wall built here does not extend down

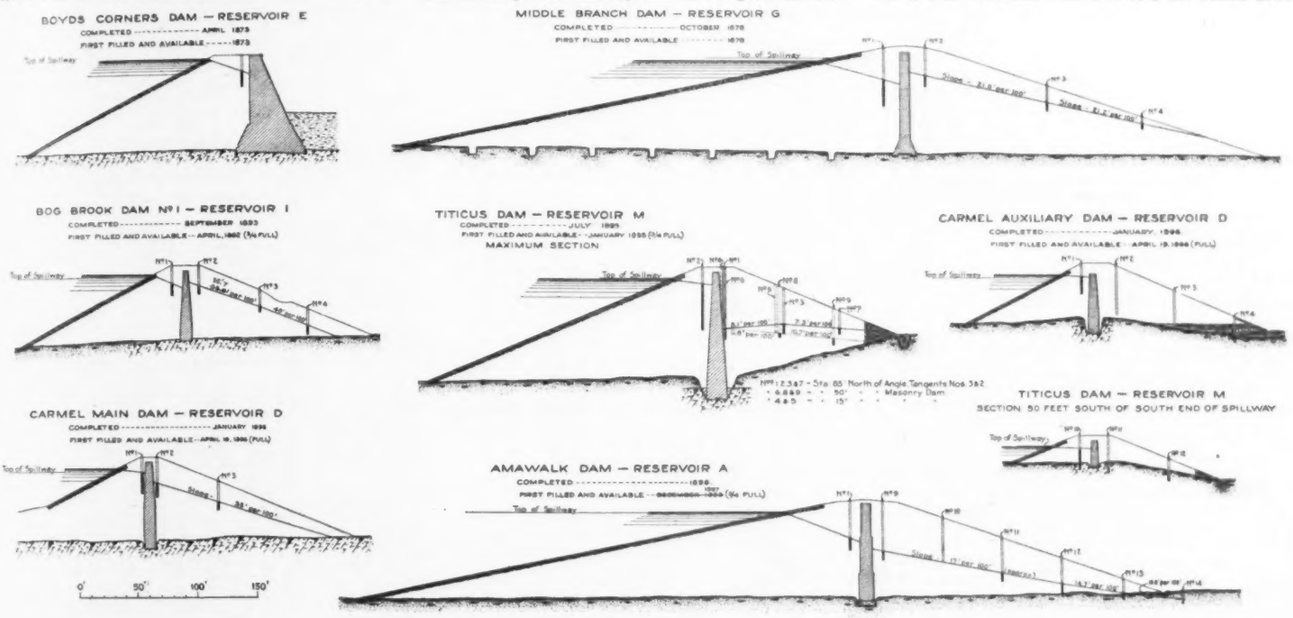

BOYDS CORNERS DAM — RESERVOIR E
COMPLETED ---------- APRIL 1875
FIRST FILLED AND AVAILABLE ---- 1875
Top of Spillway
MIDDLE BRANCH DAM — RESERVOIR G
COMPLETED ---------- OCTOBER 1878
FIRST FILLED AND AVAILABLE ---------- 1878
Top of Spillway
Slope 2:1 per 100'
Slope 1½:1 per 100'
BOG BROOK DAM Nº 1 — RESERVOIR I
COMPLETED ---------- SEPTEMBER 1893
FIRST FILLED AND AVAILABLE -- APRIL 1902 (¾ FULL)
Top of Spillway
TITICUS DAM — RESERVOIR M
COMPLETED ---------- JULY 1895
FIRST FILLED AND AVAILABLE -- JANUARY 1898 (¾ FULL)
MAXIMUM SECTION
Top of Spillway
CARMEL AUXILIARY DAM — RESERVOIR D
COMPLETED ---------- JANUARY 1898
FIRST FILLED AND AVAILABLE -- APRIL 19, 1898 (FULL)
Top of Spillway
CARMEL MAIN DAM — RESERVOIR D
COMPLETED ---------- JANUARY 1898
FIRST FILLED AND AVAILABLE -- APRIL 19, 1898 (FULL)
Top of Spillway
Slope
0' 50' 100' 150'
TITICUS DAM — RESERVOIR M
SECTION 50 FEET SOUTH OF SOUTH END OF SPILLWAY
AMAWALK DAM — RESERVOIR A
COMPLETED ---------- 1898
FIRST FILLED AND AVAILABLE ---- 1900 (¾ FULL)
Top of Spillway
Slope
Masonry Dam

FIG. 4. SLOPES OF SATURATION IN EARTH DAMS IN THE CROTON DRAINAGE AREA.

(As determined by borings made in September, 1901.)

the earth and masonry dams being at the same elevation at their junction, the top of the core-wall being 10 ft. lower than the top of the masonry dam, and the earth embankment rising to its full height only at a distance of 100 ft. from the junction. Preliminary plans for obviating this defect had been made but had never been approved by the aqueduct commission and when, a year ago, the adjustment of the top line of the dam was finally made, the possible effect of such a wave of translation was disregarded and with the idea that a level crest for the whole length of the dam would present a better appearance when viewed from down the valley, the height of the whole length of the masonry dam was increased 6 ft. and the height of the earthen dam diminished 4 ft., making the crest of the dam a level line from one end to the other at the elevation of 216 ft. above tide level. The core-wall, too, was planned to be built 10 ft. higher than before.

We consider that both the original and the present plans are injudiciously designed, in view of the possibility, remote though it may be, of such an excessive flood. If any portion of the dam is to be made an earthen embankment, it ought to be constructed at least 10 ft. higher than the crest of the masonry portion of the dam, and the masonry dam should not in any case be built higher than was originally designed. Such a change destroys the harmony and fitness of the design, which, having been scientifically determined, should be rigidly adhered to.

Another consideration which should be kept in view in the design and construction of this great work is rather aesthetic than of a purely structural character. We have

troiling the inlet to the old aqueduct be modified so as to be in conformity with the plans for the masonry dam as originally designed and now in course of construction.

JEROME PARK RESERVOIR.

The Jerome Park Reservoir is an unfinished artificial basin intended for the storage and distribution of a part of the city water supply, extending from Kings Bridge Road between Jerome and Sedgwick Aves., northerly nearly to the south boundary of Van Cortlandt Park, a distance of about a mile, with an average width of about 1,500 ft., and having a storage capacity of 1,800,000,000 gallons of water.

The surface it occupies was quite irregular and to convert it into a reservoir involved the excavation and removal of large quantities of earth and rock and the erection of long sections of retaining embankments where the surface of the ground on the limiting lines of the reservoir was below the elevation at which it is proposed to carry the water in it; and it is relative to the method that was adopted in building core-walls for certain of these earthen dams or reservoir embankments that you ask our advice.

The plans and specifications provide for lining the interior slopes of the embankment with a paving of stone or brick laid in concrete and its bottom with a layer of concrete, on good earth compacted by rolling, with the intention of making the entire interior surface of the reservoir impermeable to water. They further provide for the construction of cement masonry core-walls in all the reservoir embankments.

The data submitted to us clearly establish the fact

to the rock surface, being 30 ft. above it at the deepest point.

The borings made in this vicinity indicate that about 100 ft. south of the reservoir this depression is narrow, leaving a very contracted passage for the water which may tend to flow southward through the sand with which the depression is filled. The tests made show that the slope assumed by the water of saturation, whether undisturbed or when its surface is lowered by pumping from a pit inside of the reservoir, is northward and towards the reservoir, for about 60 ft. outside of the core-wall. From that point, the slope of the surface is towards the south. This change of direction was evident even after the water in the ground inside of the core wall had been lowered 8 ft. by pumping. The slope is very flat in each direction. The pumping for 24 hours from a pit inside the reservoir and 70 ft. from the nearest test well, seemed to lower the surface of the water, but not the slope at which it stood in the ground.

The plan of construction at this point proposes to make an embankment of selected earth, about 22 ft. in height, on the natural surface and to line the inner slope of this embankment with a pavement of brick and stone laid in mortar on concrete and to cover the bottom of the reservoir with concrete laid on a surface of good earth well rolled. The embankment is to be 20 ft. wide on top, with slopes of two to one.

Any breaks in the continuity of the reservoir lining, can, at the worst, expose but a small area of the surface of the reservoir slopes and bottom to the action of the water it stores and the character of the topography ad-

New Croton Dam, instances may be seen where it is plain that the ground water has at some quite recent date penetrated to such a pocket of hardpan, as it is termed, dissolved it, carried it to the face of the nearest steep slope and sloughed off the face, causing a landslide of the superincumbent mass of more solid material.

In a well-built earthen dam, the various classes of material are thoroughly intermingled, forming a mass better adapted to resist such action by the water of percolation, but it is never safe to permit such water to appear on the outer slope of the embankment.

In seeking information as to the actual saturation of high earthen embankments, we are unable to find any recorded data as to the penetration of water into embankments and the slope assumed by the water in passing through banks of earth artificially constructed with care.

There are in the Croton valley six earthen dams of heights varying from 50 to 90 ft., which have been in use for from three years to twenty-three years, and we accordingly secured from the chief engineer of the water department permission to test the actual extent of the saturation of these embankments by driving pipe wells into them at different points and noting the elevation at which the water stood in such pipes. The results of these observations are shown (by our Fig. 4—Ed.)

In all of the dams on which observations were made, the entire bank on the water side of the core-wall appears to be completely saturated. On the opposite side of the core-wall, water was found to be standing in the embankment in every case.

It will be observed that the extent of the saturation of the outer banks of these reservoirs varies greatly. These variations are doubtless due to the differences in the material employed in the banks, the degree of care taken in building the banks, and to the age of the embankments.

At the Middle Branch Dam, which was built by the department of public works and filled in 1878, the outer embankment near the core-wall is saturated with water to within 15 ft. of the water level in the reservoir, and ground water from a contiguous hillside and very nearly approaches the surface.

At the Carmel Main Dam, built by the aqueduct commissioners and in use since 1896, the saturation near the core-wall is within 9 ft. of the water level of the reservoir and the slope is at the rate of 35 ft. per 100 ft. towards the toe of the embankment.

At the Carmel Auxiliary Dam, water was encountered at 26 ft. below the water level of the reservoir, but on the pipe being driven down 6 ft. further, the water disappeared in a few days, showing the existence of a small pocket of water in the bank, which, being penetrated, drained out at a lower level. This indicates that the core-wall is not absolutely tight and that with the lapse of time the bank will probably become saturated until the slope of the flow in the saturated bank is determined.

The embankments of the Middle Branch and Amawalk dams were differently constructed from the dams built by the aqueduct commissioners. The same care was not required to be taken in either the construction of the core-wall or in the selection and placing of material in the embankment. In all of these embankments, the outside slope is flatter than is proposed for the New Croton Dam.

On applying the data obtained from these tests to the proposed cross-section of the New Croton Dam embankment, it appears that taking the loss of head in passing through the core-wall and the slope assumed by the water of saturation in each case examined, the maximum safe height of an earth embankment with its top 20 ft. above the water level, and its outside slope two to one, would be: On the basis of the loss of head and saturation at Middle Branch, 63 ft.; Bog Brook, 100.6 ft.; Titicus, 82.3 ft.; Amawalk, 72 ft.; Carmel Main, 102.5 ft.

In embankments of greater height than these, the outer slope would be saturated and the dam unstable and unsafe.

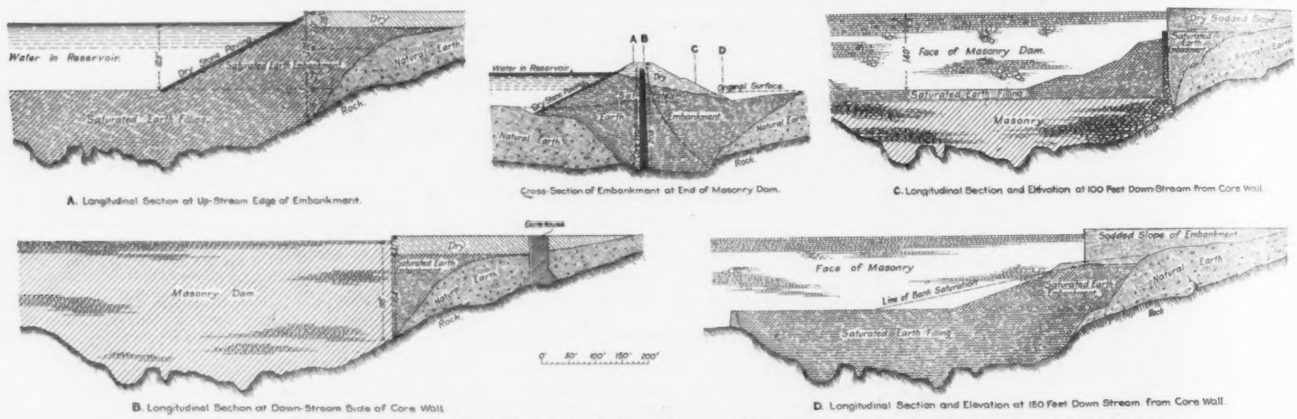
We are of the opinion that the observations made at the Bog Brook Dam, the oldest, and the Carmel Main Dam, above the water line, and with outside slopes of two to one, can be built with safety is 70 ft.

From our observations, experiments and tests of the material used in the embankments already made and the manner in which it has been put in place, we are of the opinion that the saturation in the high embankment adjacent to the masonry dam would not approach the Middle Branch rate than the Bog Brook and Carmel dams and that, at any rate, the 150 ft. of bank adjoining the end of the masonry would in time become unstable and unsafe if built as designed.

The trouble might be overcome to some extent, by flattening the slope of the banks and adding about 300,000 cu. yds. of embankment, so as to bring the probable slope of saturation not less than 10 ft. below the surface of the bank. This would extend the toe of the embankment some 250 ft. further into the valley, would add largely to the cost, and would disfigure the appearance of the dam.

Or the lack of stability might be to a considerable extent overcome by facing the lower slope with a revetment of heavy block stone paving, with a backing of broken stone. This too would disfigure the dam and add largely to the cost.

In either case, the permanent stability of the bank would be still a matter of great doubt, for it must be borne in mind that this immense bank is founded partly on a rock surface sloping down towards the valley at the rate of 50 ft. in 100 ft., and partly on the excavated face of a bank of the natural earth, which in turn rests on the same sloping rock surface. The permeability and character of this natural earth bank are unknown except where it has been cut into, and there it is found to contain a large proportion of the "hardpan" already referred to, interspersed among beds of gravel and boulders. The thrust of the embankment at its toe is resisted by a mass of miscellaneous material, dumped in and wet, but not rammed or rolled, to a depth of from 100 to 150 ft. above the underlying rock. The character of the first 50



A. Longitudinal Section at Up-Stream Edge of Embankment.

Cross-Section of Embankment at End of Masonry Dam.

C. Longitudinal Section and Elevation at 100 Feet Down-Stream from Core Wall.

B. Longitudinal Section at Down-Stream Side of Core Wall.

D. Longitudinal Section and Elevation at 150 Feet Down Stream from Core Wall.

FIG. 3. SECTIONS SHOWING PROBABLE SATURATED PORTIONS OF EARTH PORTION OF NEW CROTON DAM.

the surface of this saturation slopes away from the wall at a gradient of about 21 ft. per 100 ft., being at the lowest point noted within about 7 ft. of the surface of the embankment. The presence of water near the surface of the bank at this point is plainly indicated by the character of the vegetation on the embankment.

At the Bog Brook Dam, which was constructed by the aqueduct commissioners and has been in use since 1892, the outer embankment near the core-wall is saturated to within 7 ft. of the water level in the reservoir and the slope of saturation is 35.7 ft. per 100 ft. towards the toe of the bank, for 50 ft., and then 40 ft. per 100 ft. for 40 ft., being at that point very near the natural surface of the ground on which the bank is built.

At Titicus Dam, which was built by the aqueduct commissioners and has been in use since 1895, the core-wall has proved an impervious barrier, and there is no water in the outer embankment until a depth of 40 ft. below the reservor level is reached. The presence of this water is readily accounted for by the supposition of there being a slight flow of ground water from the natural surface, which at this point rises away from the core-wall, forming a pocket.

When this confined water finds an opportunity to escape to the toe of the embankment, it assumes a slope of 10.7 ft. per 100 ft., indicating a quite porous embankment.

At the Amawalk Dam, which was built by the department of public works and has been in use since 1897, the outer embankment near the core-wall is now saturated to within 31 ft. of the water level in the reservoir, and the slope of saturation is very uniform, at the rate of 17 ft. in 100 ft. This indicates a considerable porosity in the embankment and also that, as in the case of the Carmel Auxiliary Dam, the saturation of the bank is not as complete as may be expected in a few years. There are places on the slopes of this dam where it is evident that the percolating water of saturation is mingled with the most recent of those built by the aqueduct commission, furnish a fair criterion for assuming the probable saturation of the outer embankment of the New Croton Dam, provided that the core-wall and the embankment were built in accordance with the plans and specifications in every respect, and the foundation was on level rock.

The Titicus Dam, it is true, appears to be absolutely impervious, where the core-wall is 100 ft. high and founded on nearly level rock at the bottom of the valley, but from our examination of so much of the core-wall as has been built at the New Croton Dam, which will be 200 ft. high at one end and is built on a hillside of rock, rising 55 ft. in 100 ft., we are of the opinion that some percolation through it will unquestionably occur, and that to a degree in proportion to its height, not less than is found to occur in the Carmel and Bog Brook dams.

The slope of the surface of the saturated water in the bank is determined by the solidity of the embankment. The more compact the material of which the bank is built, the steeper will be the slope of the saturation. The evidence of the Middle Branch, Bog Brook and Carmel dams is to the effect that the bank below and adjoining the core-wall in the course of a few years becomes saturated up to 83% of the depth of the water in the reservoir, and that the slope of saturation in the best embankment made of the material found in the Croton valley is about 35 ft. per 100 ft., and that with less carefully selected and placed material the slope may be 20 ft. per 100 ft.

Comparing all the data obtainable and our observations of the character of the material employed and the work already done, we are of the opinion that in the New Croton Dam embankment the loss of head caused by the core-wall may be assumed to be 17% of the depth of water in the reservoir, or 21 ft., and that the slope of saturation may be assumed at 20 ft. per 100 ft.

On this basis, which is a liberal one, the maximum height to which an earth embankment, with its top 20 ft. ft. in height of the embankment, which has been placed on the lower side of the dam, and its behavior under exposure to the weather, will be best understood from an accompanying photograph (not reproduced.—Ed.).

Supposing, as we safely may, that an embankment 70 ft. in height may be constructed on the plans and of the material demanded by the specifications for the New Croton Dam, if founded on rock or on solid earth, with absolute assurance of its stability and permanency, an element of uncertainty is introduced when such an embankment is placed, as it is here proposed to do, on top and at the edge of an artificial bank of earth 100 ft. high, built in detached sections, as this bank must necessarily be built, and sure to be saturated with water from a reservoir 125 ft. deep behind it, and the ground water from a steep hillside adjoining it. This uncertainty arises chiefly from the fact that the settlement of a bank thus constructed must be very irregular and the liability to cracking and deformation great, being built at different times and of various kinds of material. There is no way in which such irregular settlement can be avoided. It will take place largely during and after the filling of the reservoir with water and there is no way in which cracks in the embankment which may have once opened to permit the passage of water can be closed. The percolation of water through the bank, at any but the lowest velocity, would endanger its stability beyond repair, and no amount of additional earth placed upon its slopes would suffice to make it permanently stable.

This doubt as to its permanent stability is sufficient to condemn this plan of construction for this important structure, on the permanency of which the safety of the water supply of New York depends.

The only alternative is the continuation of the masonry dam of its full section, for the remaining portion of the work. The extreme southerly end, about 130 ft. long, south of the gatehouse controlling the inlet to the old aqueduct, where the top of the dam would be 30 ft.

joining the reservoir boundary convinces us that no serious leaks need be apprehended under this section of core-wall founded on earth, and that none can possibly occur having a sufficient motion to threaten the stability of the embankment in which it stands. About 700 ft. from the east end of this section of wall founded on earth another depression in the rock surface begins, extending along Jerome Ave. 675 ft., where the wall is also founded on earth, its greatest depth under the wall foundation being 18 ft.

Along this section of wall formed on earth, the rock outside of the reservoir is evidently, from all the borings which have been made, higher than it is under the embankment, and the natural surface of the ground nowhere within a distance of 500 ft. outside of the core-wall is more than 8 ft. below the water surface of the full reservoir. We did not consider it necessary to make any test borings along the line of this wall.

About 600 ft. further north than this section, near Station 99, is another like depression in the rock surface, where, for a distance of about 250 ft., the core-wall is founded on earth, extending about 20 ft. below the bottom of the masonry.

On this section, the difficulties encountered in founding it indicates the presence there of a fine material which will run when exposed to flowing water.

The test pit and borings made near it show that the material in which this section of core-wall is founded consists of a stratum of very fine sand extending from a plane 6 or 8 ft. below the natural surface of the ground down to the rock, similar to the thin strata of fine sand in some of the borings near the first section, tested at the Kings Bridge Road.

The topographical maps and the records of the borings, in this vicinity, furnished us by your engineering department, indicate that the surface of the rock rises rapidly outside this section of embankment, and that the earth surface adjacent to the foot of its outer slope is nowhere more than 8 ft. below the water surface of the reservoir. A diagram (not reproduced) of the results of borings and pumping tests at Station 99, shows that the slope of the ground water both before being disturbed by pumping from a pit inside the reservoir and after pumping also, is toward the reservoir.

We found by numerous tests that all these fine sands are unstable when mechanically agitated in an excess of water, and that they all settle in a firm and compact mass under the water when the agitation ceases. They are quite unlike the true quicksands whose particles are of impalpable fineness and which are "quick" or unstable under still water.

From the pumpage tests, also, we are convinced that there is no danger to be apprehended from any movement of these sands sufficient to affect the core-walls. The levels taken show the slope of saturation under the embankment at both Stations 76 and 99 to be in the direction of the reservoir and not away from it as was supposed. It is evident that the ground water has not a free outlet to the south or east.

Only a small part of the embankment has been filled in along these core-walls, and they consequently produce a greater unbalanced pressure upon the fine saturated sand at their base than will exist there when the embankments are completed. No material settlement has thus far been observed in these walls, and we consider it as not within the range of possibility that the foundation will yield under the completed embankments, or that any material amount of water will find its way through or under them, if they are built in compliance with the specifications.

It must be borne in mind that the percolation of water through this bank cannot be rapid enough to induce any movement of the material and that the access of water to the material will be almost absolutely cut off by the concrete lining of the banks and bottom of the reservoir.

To preclude all possibility of the sliding or slipping of the inner bank in case of the water being lowered rapidly in the reservoir, we are of the opinion that the inner slope of the reservoir bank should be made 2½ horizontal to 1 vertical, and that at the intersection of this slope with the reservoir bottom, the interior lining of concrete should be made double the thickness that is provided for by the present plans. We recommend that these modifications be made in the plans for the construction of the embankments on the south and east sides of the Jerome Park Reservoir.

SUMMARY.

The two cases which we have had under consideration represent materially different conditions.

At the New Croton Dam, there is a reservoir of 125 ft. depth of water, retained by an artificial embankment, the outer toe of which is 5 ft. lower than the bottom of the reservoir, and which rests on a filling of earth, 100 ft. or more deep, which in turn rests on a steeply sloping rock surface. The percolation of water through this embankment to such an extent as may reasonably be expected under the existing conditions would be liable to induce sliding of the bank and its destruction. A large expenditure is warrantable to prevent the probability of such a contingency.

At the Jerome Park Reservoir there is a reservoir of 24.5 ft. depth of water, retained by an embankment from 12 to 22 ft. high, resting on natural earth 40 to 48 ft. deep, which rests on rock which is nearly level transversely to the line of the embankment. Beyond the embankment, the surface of the ground generally rises, but in a few instances falls away very gradually. There is no possible danger of sliding or sloughing of the bank. The utmost that can be anticipated is the seepage of a small amount of water through the embankment and the earth, and this would be carried off by the sewers in the adjacent avenues. A large expenditure to absolutely prevent such seepage would not be warranted nor advisable.

In conclusion, we desire to express our thanks to your honorable board for the liberal assistance afforded us in our investigations, and the aid most efficiently furnished by your Chief Engineer, Mr. William R. Hill, C. E., and his staff, with whom all the questions at issue have been thoroughly discussed.

We further wish to express our obligations to Mr. Alphonse Fteley, C. E., by whom the works under examination were designed and partially constructed, for his very full explanation and discussion of the principles which guided the design and specifications for the dam and reservoir; and to Mr. George W. Birdsall, Chief Engineer of the Water Department, for the facilities afforded us in the examination of the existing earthen dams in the Croton watershed.

MEMORANDA BY MR. SWEET.

I have the honor to file with your honorable board the following brief memorandum of the additional considerations which have influenced my mind in reaching the conclusions announced in the joint report on the Croton Dam made to you by the board of consulting engineers of which I am a member.

Composite dams, which, like the New Croton, are built partly of earth and partly of masonry, constitute a distinct class or type which has its most numerous and conspicuous examples in this country.

The boldest example among completed reservoirs of this type is afforded by the dam impounding the Titicus branch of the Croton River, known as Reservoir M of your Croton storage system.

The maximum height of the earthern part of the Titicus Dam is about 110 ft., and the height of its core-wall where it joins the dam is about 115 ft.

The effective height, however, is much less than the greatest height which occurs where the dam crosses a bend in the old channel and does not at any point exceed 70 ft. The effective height at any point of an earthen dam may be defined as the difference of elevation of the highest water surface in the reservoir and the elevation of the intersection of the outer slope with the natural or restored surface of ground below the dam. Applying this definition to the embankment of the New Croton Dam, the cross-section we give in Plate No. 1 (see [illegible] 1—Ed.) shows its effective height to be 130 ft.

Plate No. 1 in the appendix hereto shows [illegible] maximum cross-sections and effective heig[illegible] of the earthen parts of the Titicus and the New C[illegible] Dam, and of several of the highest earthen dams in [illegible] country and in England (not reproduced; but see [illegible] Figs. 3 and 4—Ed.).

Composite dams of great height designed like [illegible] compare unfavorably with continuous earthen [illegible] first, because of the facility they afford for water [illegible] follow the face of the masonry dam to the core-wall, [illegible] second, because the much greater unit pressure on the [illegible] portion of the latter, due to gravity, tends to [illegible] it near its junction with the masonry dam; and third, where, as in the New Croton Dam, the foundation is at a great depth from the original surface, because of [illegible] amount greater depth of artificial embankment made necessary by the excavation incident to founding the adjacent part of the masonry dam.

A glance at the typical sections of high earth dams shows that some have core-walls extending down a great distance below the natural surface of the reservoir site, but where the core-wall trench is completely filled with the core-wall, this does not affect their effective height, since the frictional resistance of the earth [illegible] the water pressure and the tendency to leak to diminish as the depth below the original surface at the bottom of the reservoir increases.

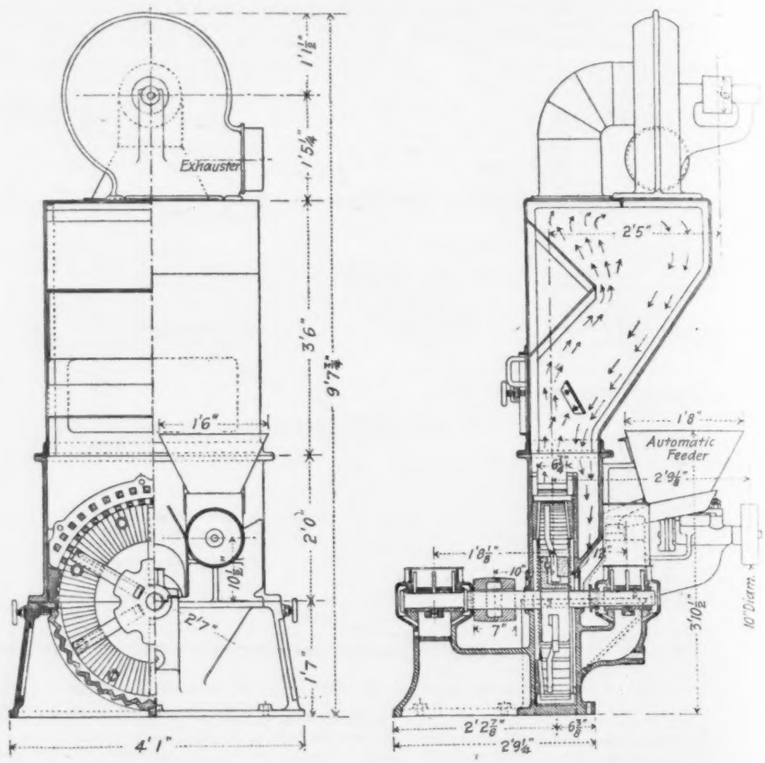


FIG. 1. SECTIONS OF PULVERIZER FOR GRINDING COAL; CYCLONE PULVERIZER SYSTEM OF POWDERED FUEL COMBUSTION.

This part of the Croton Dam differs from any of the earthen dams which approach it in height in that, on account of the wide excavation made necessary for founding the adjoining masonry dam, the highest part of its core-wall stands in an artificial embankment, 200 ft. high, while they have artificial embankments little more than half this height, with core-walls in trenches extending down to the solid rock through the natural formation. It differs from them in having a core-wall of masonry instead of puddled earth, a difference which may prove dangerous in very high embankments where excessive pressure might effect deformation sufficient to break the masonry core-wall, but would not disturb the continuity of the more plastic puddle wall.

No like structure so high exists connecting at its greatest height with a masonry structure as this does in a manner that makes leakage near their junction more likely than where the earthen dam extends entirely across the valley. Nor is there any with an upstream slope so steep as this is designed to have.

Another peculiarity of this construction is the character of the rock on which it is founded, which is shown by the history of the excavations made for the founding of

the masonry dam and the core-wall to be a soluble limestone, having a vertical dip, and a strike following the valley and at right angles to the line of the dam, diversified with belts of varying width which were full of eroded seams and cavities, through which water flowed freely during the excavation, or masses of stone broken up by seams running in all directions which were filled with mud.

Though the excavation of (for?—Ed.) the core-wall was doubtless carried to sound rock it was only 18 ft. wide and it seems from the conditions developed in the excavation 200 ft. wide for founding the masonry dam

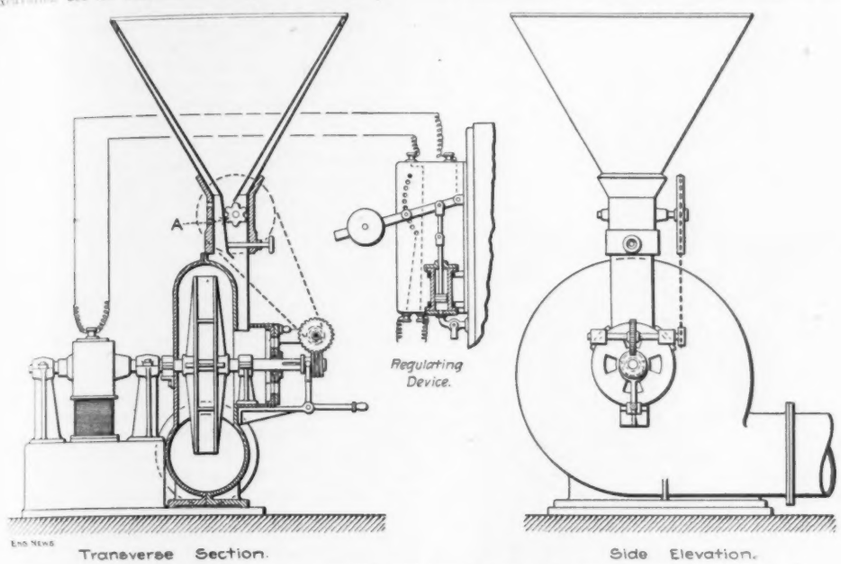


FIG. 2. SECTION OF COAL DUST FEEDING DEVICE; CYCLONE PULVERIZER SYSTEM OF POWDERED FUEL COMBUSTION.

that there may exist seams or cavities underlying this core foundation which may, when the immense head of 130 ft. of water is put in the reservoir, develop leaks endangering the embankment, as they may possibly reach the surface of the rock directly under the embankment, below the core wall, and may saturate the front embankment and endanger this part of the dam.

The distrust which high earthen dams create in the minds of conservative engineers is not far to seek. The engineer appeals to exact science in vain for guidance in their construction. It furnishes no approved method of determining their internal stresses, and so endless are the varieties of the earths in the glacial drifts that usually cover the sites of such structures, that every new project of this character presents a new problem to which the engineer must apply what to his mind are the most appropriate precedents, since the art of earthen dam construction is purely empirical.

However high such dams may be, they must be built of earthy materials, all of which are to some extent permeable to water, and their degree of permeability depends on their infinite variability of geological and physical character and increases with the head of water which they sustain. All these materials are more or less soluble in water, and a small leak once developed is likely to grow and may destroy the structure.

We have made numerous tests and analyses, to determine the behavior in presence of water, of the materials contained in the embankment now built, as well as to ascertain their physical condition and their geological classification, and I am of the opinion that the mixture of earth found in it is not well suited for making durable reservoir banks. A study of the tests and experiments detailed in the annexed appendix is invited to justify this conclusion. This mixture of earths has a pretty high coefficient of frictional resistance to the passage of water, but with an excess of water it is exceedingly unstable, making it peculiarly dangerous if a leak develops.

A careful study of the earths found in the vicinity of this dam leads me to believe that better materials are not readily accessible.

For immunity from leaks we must rely on the integrity of the core-wall and that it be founded in absolute impermeable material.

Though I do not consider the deformation of the core-wall or the development of dangerous leaks through it to be highly probable, I believe, for the reasons cited, that their occurrence is entirely possible under a difference of pressure above and below the wall due to a head of 130 ft. The flattening of the slopes of the embankment would lessen, but would not in my opinion remove, this risk.

To fully comprehend how essential the permanence of this structure is to the water supply of New York, it is necessary to bear in mind that it creates an artificial lake 16 miles long, extending more than 12 miles above the Old Croton Dam, where all the water now supplied by this watershed is drawn through the old and the new Croton aqueducts and that it submerges the old dam 34 ft.

The failure of this embankment would not only create a devastating flood in the valley below it, but it would create such an irresistible velocity of current above it as would certainly destroy the earthen part of the old Croton Dam, and probably the masonry portion of that dam which is founded in earth, at once cutting off the sole water supply of Manhattan Island, causing an absolute water famine for the vast population dependent on this Croton supply, with all its attendant domestic hardships and the paralysis of trade and industry until the old dam could be rebuilt or repaired, and it would defer indefinitely the time when the city could have the additional supply of water which the new reservoir will furnish when completed.

Having in view, therefore, the magnitude of the disaster that would follow the sudden release under this head of the 30,000,000,000 gallons of water that are retained by this dam, it becomes clear to my mind that the execution of this plan will create risks not lightly to be assumed if a safer construction is attainable.

The necessity for the permanence of this vast structure makes any condition less than absolutely certain stability inadmissible in its design and its construction.

During the last half of the century just closed the subject of the proper design of high masonry dams engaged the attention of the best scientific thought abroad and in this country, resulting in designs and examples that create a profound conviction that masonry constructions alone afford adequate certainty of permanence where dams are required of the height attained by the earth dam we are considering as they preclude dangerous leaks and all the stresses occurring in them are readily ascertained and provided for.

The masonry part of this new reservoir dam is designed in accordance with thorough scientific investigation and similar construction should be substituted in place of the embankment from the south end of the present masonry dam to the Gate house, a distance of about 200 ft.

TWO RECENT SYSTEMS FOR BURNING POWDERED COAL.

We illustrate in the accompanying cuts the general details of two different apparatus for burning powdered coal which have recently been applied, apparently with good success, at several works in America. The first of these devices was developed in England, and is known as the "Cyclone" pulverizer. This apparatus is controlled in America by the Jessup Cyclone Pulverizer Co., 15 Cortlandt St., New York city. The second device described is known as the "Aero-Pulverizer." It is an American invention, and is controlled by the Aero-Pulverizer Co., 10 Wall St., New York city. In our issue of March 14, 1901, we described and illustrated a new method of burning powdered coal, invented by the late Wm. Westlake, and developed in respect to its working details by Faber du Faur & Donnelly, engineers, of New York city, and in the succeeding issue of June 20, 1901, a full description was given of the powdered fuel plant at the works of the Alpha Cement Co., at Alpha, N. J.

CYCLONE PULVERIZER SYSTEM.—The cyclone pulverizer system of powdered coal combustion comprises an apparatus known as a cyclone pulverizer for reducing the coal to powdered form and another for feeding the pulverized fuel to the furnaces, which is known as a cyclone feeder. The construction of the pulverizer is shown by Fig. 1. In this machine the grinding is down by attrition between the arms of a rapidly-revolving star and the serrated sides and periphery of a steel casing. The coal is fed into the casing from a hopper at one side, and when ground is withdrawn into a separating hood surmounted by an exhaust fan. In operation, the arms of the star have a circumferential velocity of from 15,000 ft. to 20,000 ft. per minute, which drives the coal around at high speed and beats it against the serrated casing. As the flying coal dust passes into the top portion of the casing it comes within the suction of the exhauster, and such portions as are fine enough to be carried by the air current are withdrawn and delivered into a dust collector, the air passing on to escape through canvas tubes or to be returned to the separator for further use. By regulating the speed of the fan any degree of fineness desired may be secured, since only those particles of such specific gravity as the air current will counteract are withdrawn, all others being returned to the pulverizer for further grinding.

The feeding device, for feeding the pulverized

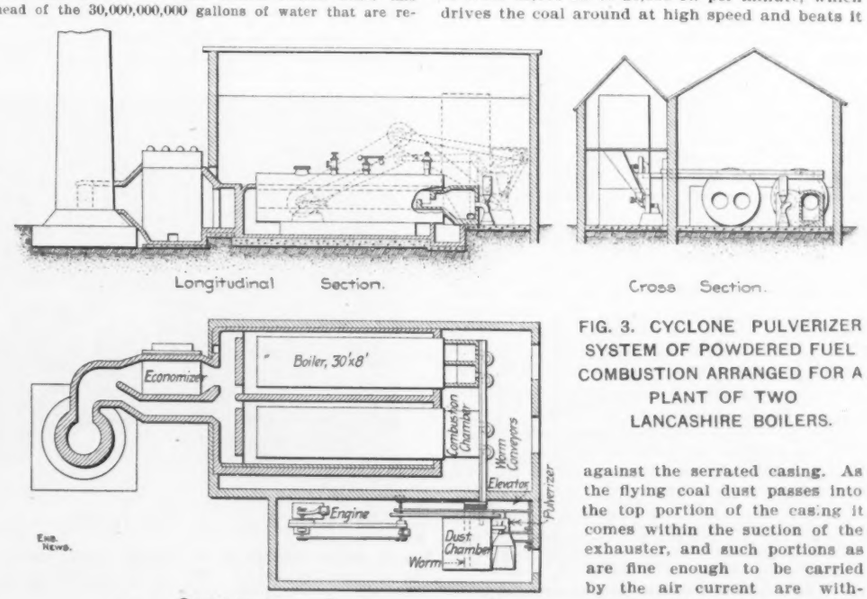


FIG. 3. CYCLONE PULVERIZER SYSTEM OF POWDERED FUEL COMBUSTION ARRANGED FOR A PLANT OF TWO LANCASHIRE BOILERS.

coal to the furnace, consists essentially of a centrifugal fan surmounted by a hopper having a feeding device at its bottom, and with the suction end of the fan closed by a damper which regulates the amount of air admitted. Fig. 2 shows one form of feeder. The admission of the coal dust to the fan is regulated and controlled by a serrated roller arranged and operating as shown at A, Fig. 2. This feeding device effectually prevents the coal dust from bridging over the opening at the bottom of the hopper. The dust as it is fed through the roller drops into the suction pipe of the fan, where it meets the incoming air and is drawn in, to be caught by the blades, stirred up and passed out of the fan into the furnace in the form of a dense cloud. The amount of air can be regulated independently of the coal by means of the damper, and the amount of coal fed by one revolution of the roller can also be regulated. The feeding device and the fan are connected by gearing, so that having once set the damper and feed, the proportions of air and coal remain the same even though the speed of the fan be increased to increase the quantity of each.

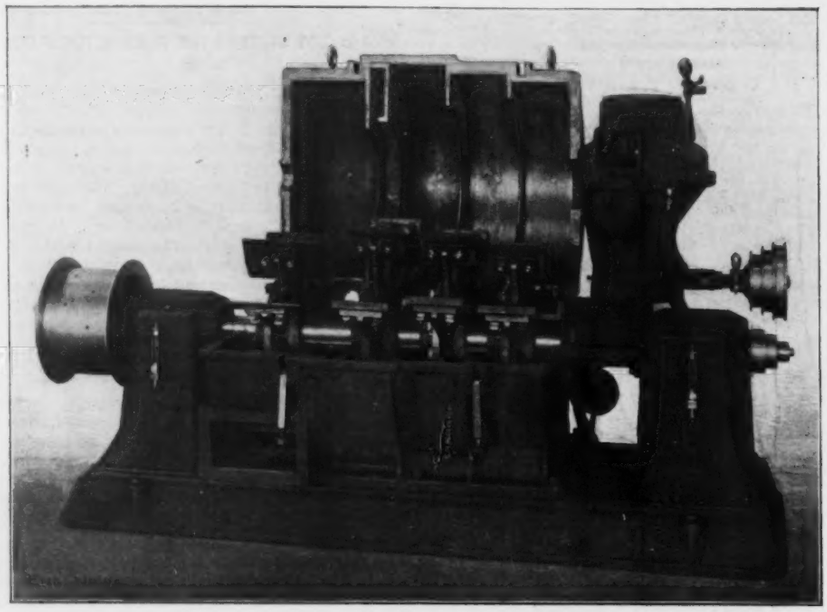


FIG. 4. VIEW OF AERO-PULVERIZER AND FEEDER FOR POWDERED FUEL COMBUSTION.

Fig. 3 is a general plan, which has been furnished to us by the Jessup Cyclone Pulverizer Co., showing an arrangement of a plant for coal-dust firing. The drawings explain themselves, and no comment is necessary. To start the fire, when using this apparatus, a fire of wood or oily waste sufficient to heat the fire-brick lining of the combustion chamber to a temperature that will ignite the blast is first started. The ashes are carried by the blast over the bridge wall and fall in the back connection, whence they can be removed by any suitable means. The advantages claimed by the manufacturers of this system of powdered fuel combustion are as follows:

(1) Absence of smoke: When the proper amount of air is furnished absolutely no smoke is formed.

(2) Reduced labor expenses: The machines being automatic, require but very little attention, and one man can feed a great number of furnaces.

(3) Adaptability and ease of regulation: The fire may be started, stopped, increased or diminished at a minute's notice, simply by the speed of the fan.

(4) Decreased wear and tear on the furnaces: The fire is of a steady and uniform heat, and no sudden changes of temperature such as that caused by opening the doors for hand firing occur.

(5) Intimate contact of the fuel with the air: Whereby a minimum excess over the theoretical volume is required, thus saving the waste heat carried away in the flues by the great amount of air required for ordinary coal burning.

(6) The complete combustion of the fuel: Owing to the fact that the air completely surrounds each little atom of coal, while in the lump coal firing the innermost particles of the coal cannot be reached by the air at all.

(7) Less labor in removing refuse: This can be run off continuously by conveyors, requiring no labor at all, and owing to the complete combustion of the fuel it is a much smaller amount than in the case of an ordinary fire.

(8) Increased capacity of the boilers: The coal being in such intimate contact with the air, combustion is almost immediate, and consequently a greater amount can be burned in a given fire-box per hour. Between 6 and 7 lbs. of water per square foot of heating surface have been evaporated with an easy, safe and smokeless combustion.

The matter of economy has been amply demonstrated by various tests made with great care and which showed the percentage of heat units in a given fuel actually utilized, to be from 20% to 25% higher than when the same boiler was fitted with grates and fired with the same coal unground. Many tests have been made showing an efficiency as high as 80%, whereas the working of similar boilers is more often below 60%. In Germany, the owners of a large Portland cement works have just put on record that they are enabled by this system to use coal containing over 40% of ash, costing only one-fourth the price they formerly paid. Tests on a Cornish boiler were made in Berlin, first with coal about No. 2 Buckwheat, hand fired, and then the same coal pulverized to pass a 100-mesh sieve. The total heating surface was 500 sq. ft., and the thermal efficiency of the boiler was 58% by hand firing and 77% with the powdered coal. Of course, against this gain of 20% to 25% and a reduction of the labor expense, is the cost of grinding the coal, which varies from 15 to 25 cts. per ton, depending upon the nature of the coal, the moisture present, and the amount of grinding undertaken.

AERO-PULVERIZER SYSTEM.—The distinctive feature of the aero-pulverizer is that a single machine serves both to powder the coal and to feed the powdered dust to the furnace. The general construction of the machine is shown by Fig. 4, in which the upper part of the casing appears thrown back so as to give a view of the interior mechanism. Briefly described, the machine consists of three interiorly communicating chambers of successively increased diameter, in which revolve paddles on arms having lengths corresponding to the diameters of the chambers in which they work. The fourth chamber shown at the left hand contains a fan, whose function it is to draw the pulverized material from one chamber to the other and finally deliver it through the exit in the fan chamber under the impulse of a forced blast. At the right hand end of the machine is the automatic arrangement for feeding the large coal to the pulverizer proper. There are two adjustable inlets for air at the feed end of the machine through which is introduced the amount of air required for pulverizing purposes, and there is an auxiliary chamber between the third pulverizing chamber and the fan chamber, the inlet of which is at the top of the machine and through which is introduced such additional air as is required to bring the total supply of air up to the amount theoretically required for combustion.

From the preceding brief description of its construction it will be evident that the operation of the machine is substantially as follows: The coal is introduced into the hopper surmounting the feeding device and is thence fed regularly and automatically into the first grinding chamber. All sizes of coal that will enter the machine may be used at one time, but to get a perfectly uniform feed it is desirable to crush the coal so that the largest pieces will pass a 1½-in. ring. The moisture in the coal, it is stated, is a relatively unimportant matter so far as fineness of grinding is concerned, but wet coal requires somewhat more power to grind it and it is, therefore, desirable to have it contain not more than 10% moisture. The grinding is done between the edges of the paddles and the periphery of the casing, and each succeeding set of paddles produces a finer powder than the set preceding. The final product is a practically impalpable powder, of which from 90% to 95% will pass a 100-mesh sieve. This powder is drawn into the fan chamber and expelled directly into the pipe which feeds the furnace. Referring to this latter feature, the manufacturers write us as follows:

Our claim is strictly that this one self-contained machine does all the work within itself, doing away (1) with all preliminary drying of the coal, (2) grinding or pulverizing with a special machine with the usually resulting necessity of screening, and (3) storing the product and having another mechanical device to mix the dust with air and deliver it to the point of combustion. Given our machine and the delivery pipe (which obviously varies in form with different local conditions) and you have all there is. The pulverizer can thus be placed in any position relative to the combustion chamber, even above or below, as well as on either side, the pipe with its requisite curves making the proper connection between the two.

Fig. 5 shows a portion of the kiln house of the Michigan Portland Cement Co., at Coldwater, Mich., which gives a view of the discharge ends of a battery of seven rotary kilns supplied with powdered coal by aero-pulverizers. Another battery of seven kilns is located on the opposite side of the house. The peculiar arrangement of the feed pipes shown was made necessary by the fact that a passageway for men and wheelbarrows was required between the pulverizers and the ends of the kilns.

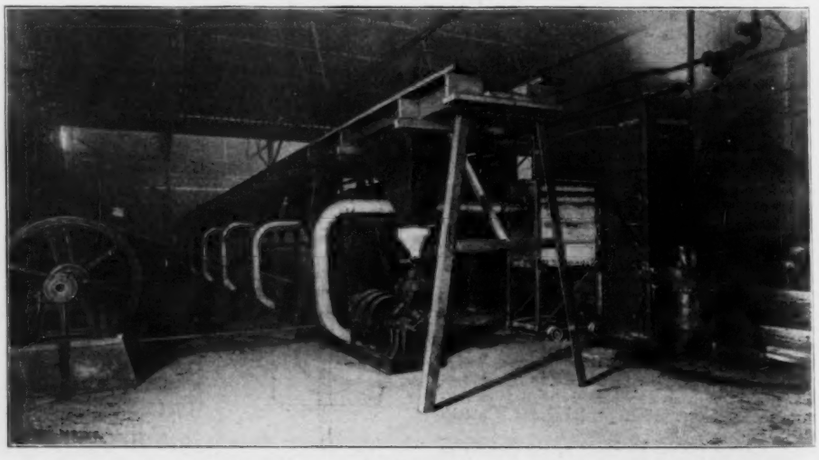


FIG. 5. KILN HOUSE OF MICHIGAN PORTLAND CEMENT CO., SHOWING AERO-PULVERIZERS FOR FIRING ROTARY FURNACES.